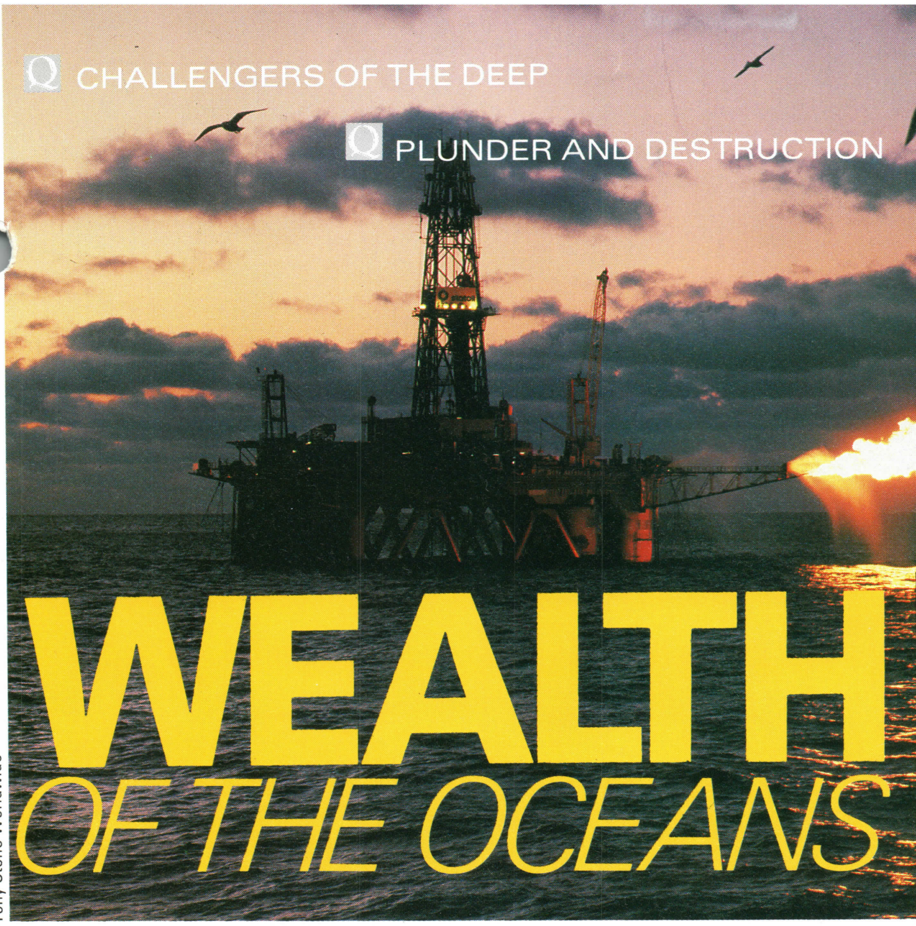
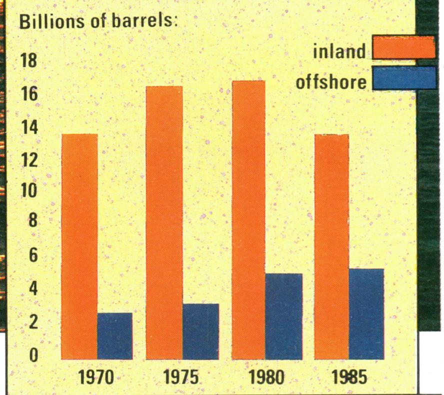
CHALLENGERS OF THE DEEP
PLUNDER AND DESTRUCTION
TREASURES



Tony Stone Worldwide

WEALTH
OF THE OCEANS



WORLD OIL PRODUCTION

The increase in world oil consumption since 1970 has led to a rapid increase in offshore drilling. By the mid-1980s it contributed about 28 per cent to world production.

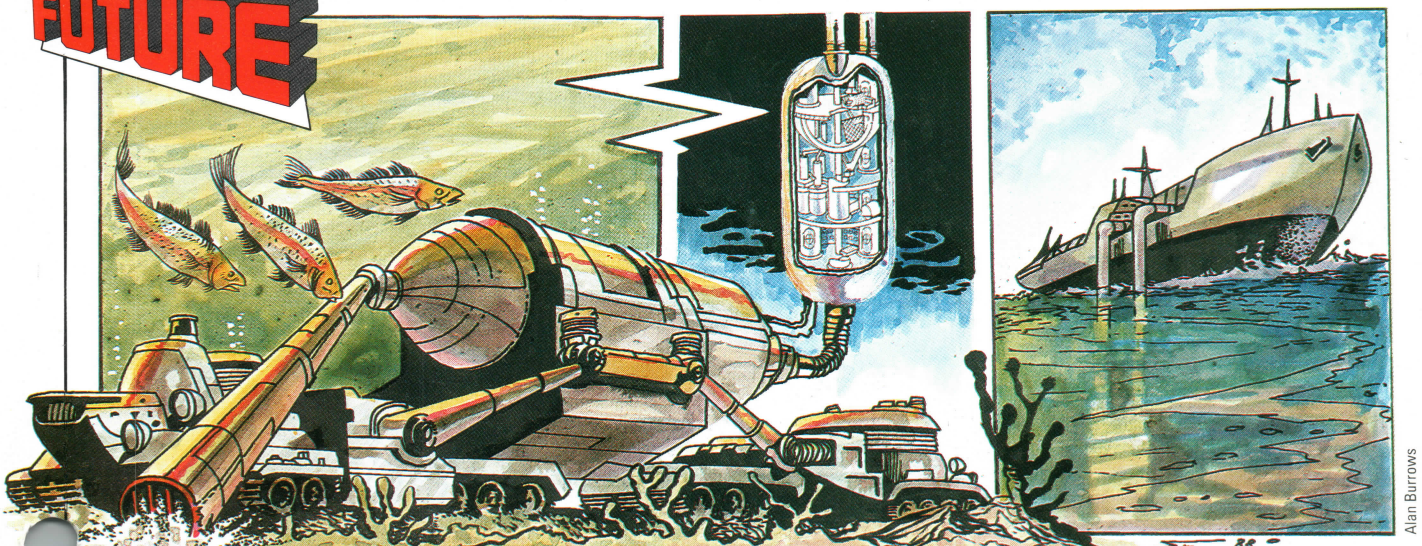
Mark Franklin

THE OCEANS AND THE SEAS present many challenges. They contain enormous quantities of materials valuable to Man. But, in most cases, obtaining these materials presents great difficulties or dangers.

The oceans abound with useful minerals, but most are too costly to extract from the vast volumes of water. Oceans cover more than 360 million square km of the Earth's surface, and contain around 1,400 million cubic km of water. Fish, on the other hand, are relatively easy to catch and Man could very easily endanger future supplies by over-fishing. Although the oceans are a tempting dumping ground for waste products, there is an urgent need to avoid harming plant and animal life by polluting the waters with sewage and chemical waste.

INTO THE FUTURE

HARVESTING THE OCEANS

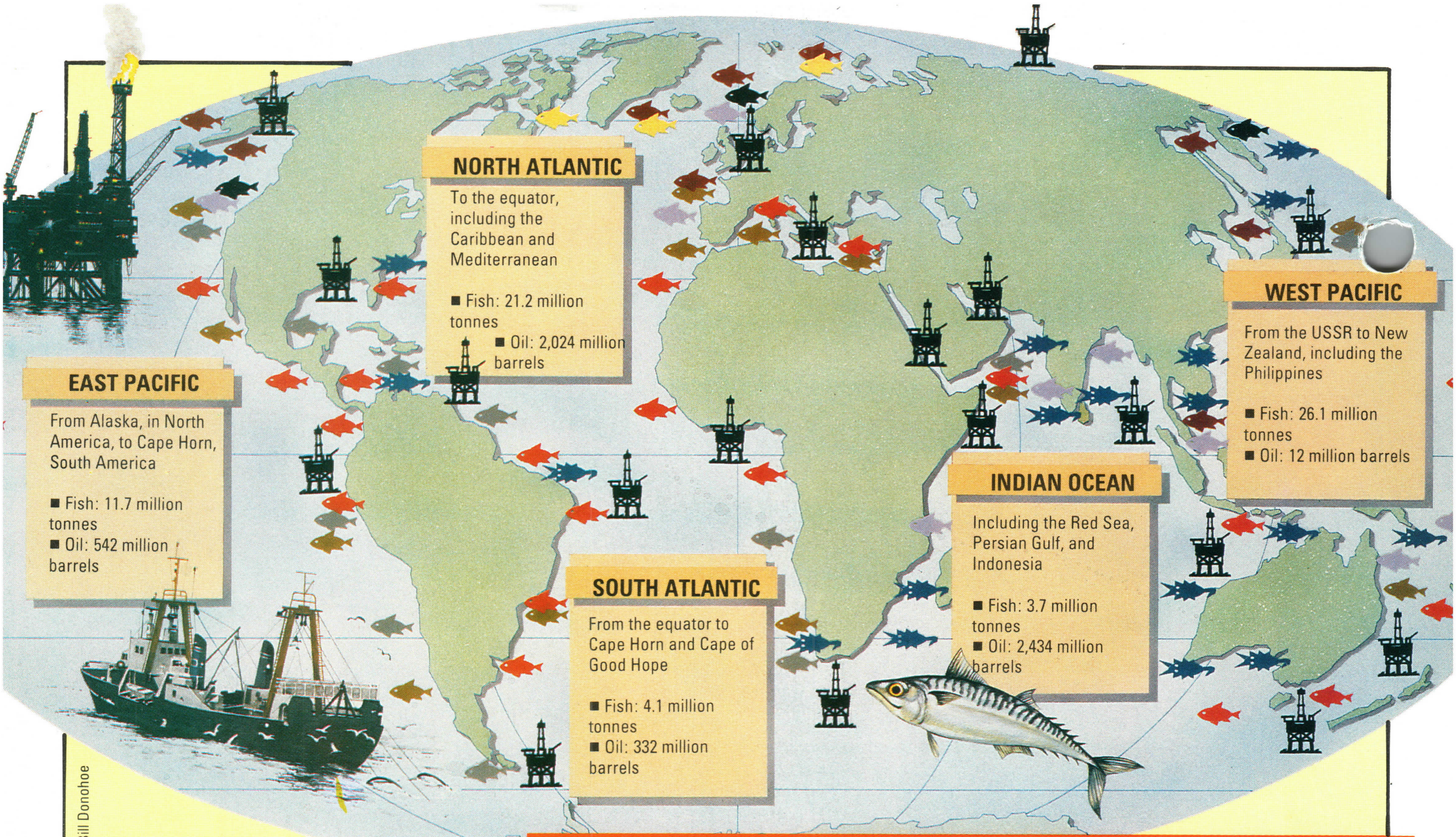


Alan Burrows

▲ *Powerful underwater tractors could be employed to harvest mineral-rich manganese nodules that lie scattered over the ocean floor.*

▲ *Manganese nodules would be sucked up and passed through a tube to a nearby processing chamber where they would be ground down to a powder.*

▲ *From the chamber, manganese powder would be transferred to the hold of the mother ship, then taken to a refinery where precious metals would be extracted.*



Bill Donohoe

THE OCEAN'S RESOURCES

KEY

- anchovy
- sardine
- cod
- herring
- capelin
- tuna
- mackerel
- crustaceans
- oil/gas rigs

The symbols show the most important areas in the world's oceans for fishing and oil production. The most productive regions for oil and natural gas lie close to the edges of the continents. Some coastal waters also yield some coal and metals, notably iron, titanium and tin.

Offshore oil production started in California in the 1890s and, as recently as 1960, about 90 per cent of offshore rigs were around the coasts of the United States. Since then, the great potential of offshore oil reserves has been exploited by many other countries. Now, more than three-quarters of all oil rigs are in other regions.

Whereas oil reserves are certain to become used up, the oceans' fish resources could provide us with food indefinitely. However, the rate at which fish are taken will have to be carefully regulated to ensure that stocks are maintained.

Gold, silver and uranium are among the 58 billion tons of solids in the oceans. But these precious metals occur in such minute quantities that the cost of extracting them would be more than their value – at least, at present. On average, each one million tonnes of sea water contains about 1,500 g of uranium, 300 g of silver, and only 6 g of gold.

Mineral wealth

Magnesium is the most valuable substance extracted, but common salt is taken in the greatest amounts. However, it is the ocean floor that yields most of the mineral resources. Vast oil and gas reserves locked beneath the surface are tapped through boreholes. About 250 wells are in operation in the North Sea alone. Yet the North Sea is one of the most inhospitable seas on the planet. With waves up to 25 metres high and winds of 200 km/h, living conditions on North Sea rigs are particularly dangerous. Rescue from these rigs, in the event of an accident, is fraught with danger.

In the deep oceans, especially below 4,500 metres, strange potato-shaped deposits known as manganese nodules are found. These are packed full of valuable materials – not just manganese, but also nickel, cobalt and copper. So too are the manganese crusts, which occur as coatings several centimetres thick on some rocks. These are found in shallower waters.

Manganese nodules will become an important source of metals once scientists have developed an economic method of collecting them.

Watery treasures

Pearls come from oysters, which were once gathered by skin divers. Nowadays, pearl culture is a highly organized business, especially in Japan. To start a pearl developing, a small 'nucleus' is placed within the soft tissue of the oyster. The original pioneers used small glass beads and lead shotgun pellets. Shell pellets are used now as they work much better.

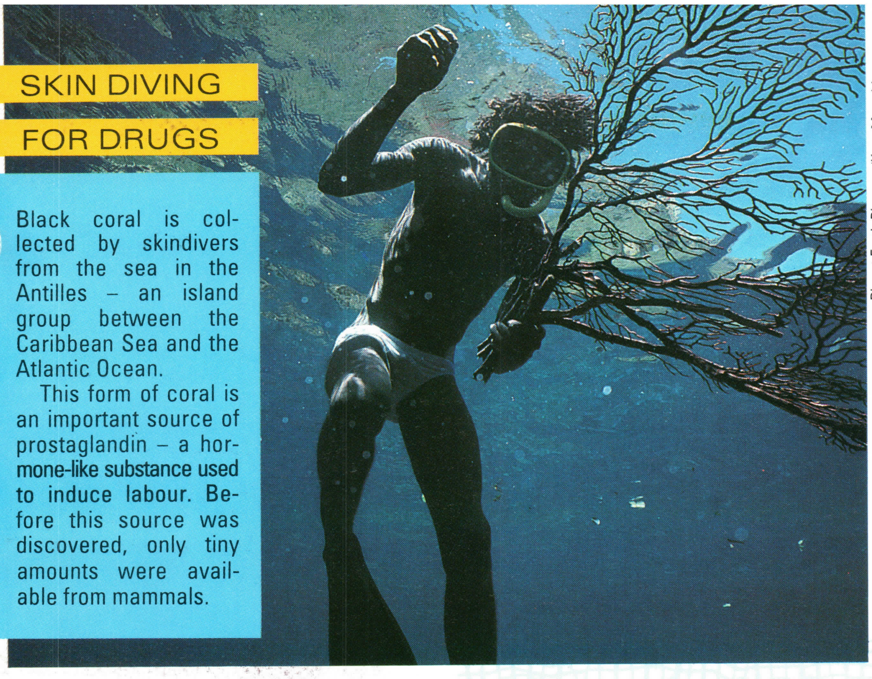
Fifty years ago, it was a struggle to make cultured pearls even 3 mm across. Now they may be as large as 10 mm. Despite their impressive size, they consist mostly of the nucleus. The outer pearly layer is beautiful and transluscent, but only a few millimetres thick.

Precious coral is a type of sea fan that lives only in deep water. Delicate pink jewellery is made from this creature by skilfully working the stem of the fan.

Sea food

Huge amounts of food are present in the oceans, but only about three per cent of the world's food supply actually comes from the sea. One reason for this is that many people, especially in the West, are not great eaters of seafood. In the Far East, people are much more adventurous. Strange creatures such as sea cucumbers are a favourite among the Chinese, who also eat jellyfish and sea urchins.

Another unusual sea food is the Pacific palolo worm. In Polynesia, a great feast is held every year to celebrate the spawning of this sea creature. When the reproductive hind ends of the worms are cast off into the water, they are scooped up in enormous quantities. This strange harvest is then made into soup.



Planet Earth Pictures/Krov Menuhin

SKIN DIVING FOR DRUGS

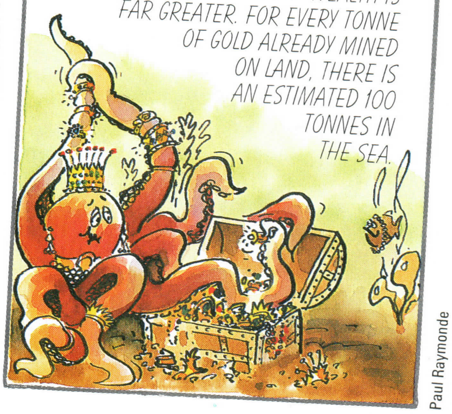
Black coral is collected by skindivers from the sea in the Antilles – an island group between the Caribbean Sea and the Atlantic Ocean.

This form of coral is an important source of prostaglandin – a hormone-like substance used to induce labour. Before this source was discovered, only tiny amounts were available from mammals.

Just amazing!

LIQUID GOLD

ALTHOUGH MAN CONTINUES TO MINE THE EARTH'S RESOURCES AS FAST AS HE CAN, THE OCEANS' WEALTH IS FAR GREATER. FOR EVERY TONNE OF GOLD ALREADY MINED ON LAND, THERE IS AN ESTIMATED 100 TONNES IN THE SEA.



Paul Raymonde

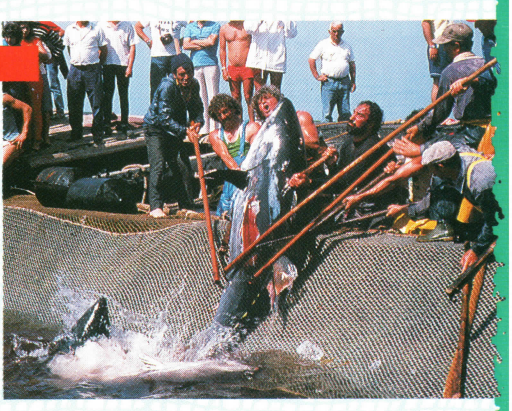
Around 75 million tonnes of fish are taken from the oceans each year. Anchovies, herrings and sardines are all small, shoaling fishes that feed on tiny organisms floating in the water. Bigger fish, such as mackerel and tuna usually eat the smaller species.

The seaweed crop is tiny compared with that of land plants. Most seaweeds are too small to collect as food. And even the larger species are not highly nutritious. However, in the Far East about a million tonnes of wet weed are taken each year for food. Much of this seaweed is cultivated.

TACKLING THE TUNA

Bringing tuna aboard a fishing boat in the Mediterranean Sea is the first stage in a production line that ends up with the tin on a supermarket shelf. This huge, agile creature eats large quantities of smaller fish, and outweighs a man by the time it has reached the age of five years. It commonly weighs around 200 kg at the age of ten, and it doubles this weight by the age of 25 – if it is fortunate enough to live that long.

Gamma/Frank Spooner Pictures

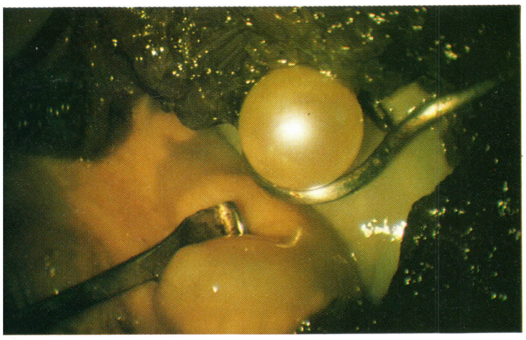


Drugs and plunder

Many compounds have been discovered in ocean plants and animals. Some can fight disease, while others stimulate the heart, control blood clotting, or influence the workings of the nervous system. Cytotoxins, from sea cucumbers and sea fans, are important in destroying cancer growths. And black corals provide prostaglandins used to stimulate muscle contractions.

Throughout history, pearls have been thought to have medicinal properties. Claims are made that pearl powder can cure indigestion, malaria, leprosy, insomnia and many other ills. However, scientists are not yet convinced that such claims are anything more than mere superstition.

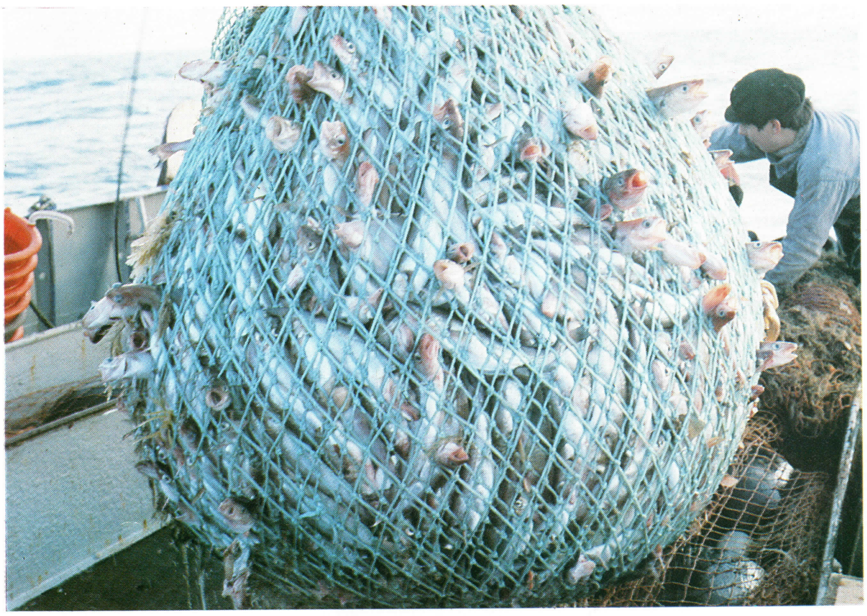
Big boats, modern fishing gear and sonar systems to detect fish heralded the beginnings of serious over-fishing. These innovations meant that, instead of just a few fish being caught, they were scooped from the water by the tonne. As more boats and fishermen joined the hunt, working long hours out at sea, the harvest became enormous. Now warning bells are sounding, for those species being exploited are on the decline.



Michael Freeman

__A cultured pearl__ is revealed for inspection by the latest photographic techniques, allowing us to see inside a live oyster.

__Cod and haddock__ is hauled aboard a 'wet-fish' trawler in the North Sea. The catch is brought back to shore to be frozen.

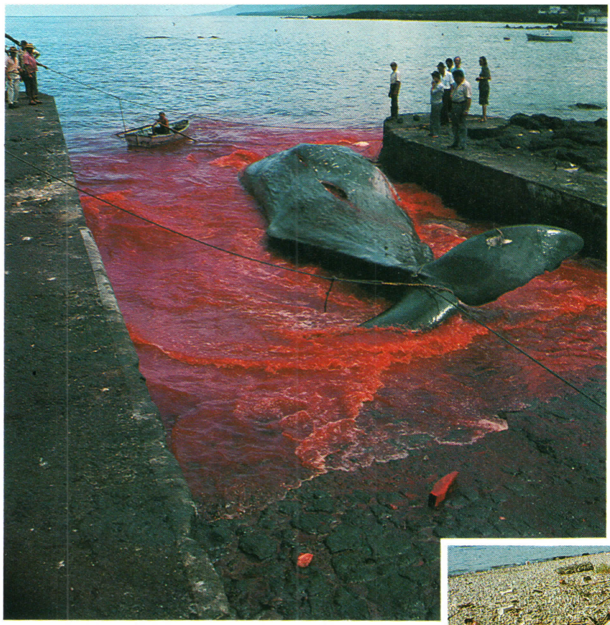


Zefa

In the North Sea, some stocks of herring and mackerel dropped to a point where tight controls and catch quotas had to be introduced to allow the populations to recover.

The exploitation of whales is one of the saddest stories of all, partly because of the inhumanity involved in the slaughter of these intelligent giants. Since commercial whaling began over one hundred years ago, some species have been brought to the brink of extinction.

The blue, humpback and bowhead whales have all become endangered, with populations dropping to as little as one tenth of their original level. International legislation has now been introduced, but some nations are unwilling to cooperate with the restrictions and so these whales are still under threat.



Planet Earth Pictures/Jonathan Gordon

A sperm whale *is pulled ashore – its blood turning the sea red. The location is Pico, one of the Azores islands in the North Atlantic. The sperm whale is the largest of the toothed whales. When fully grown, it reaches more than 18 metres in length. Despite warnings about endangering the whale population, some countries still allow these huge creatures to be caught.*

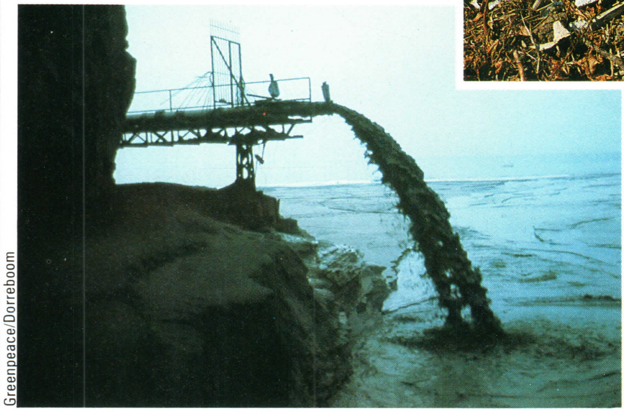
Man – the polluter

The seas are immense, and it is tempting to assume that waste dumped there will be diluted and whisked away by the currents. Sometimes this is true, but not always. Huge quantities of waste are involved, most of it is dumped in shallow coastal waters, and some of it is extremely dangerous. Besides sewage, toxic heavy metals, such as lead, mercury and cadmium are dumped in the sea. In the 1950s, over 2,000 people were poisoned, 43 killed and 700 permanently disfigured at Minamata in Japan, after eating fish and shellfish contaminated with mercury from a local factory.

Dangerous pesticides also wash into the oceans, either directly or via rivers. These substances are taken up by marine plants and animals, and can badly affect their growth and health. Worse still, they often accumulate both in the environment and in living organisms. In this way they enter food chains and become more concentrated at each link in the chain.

Zefa

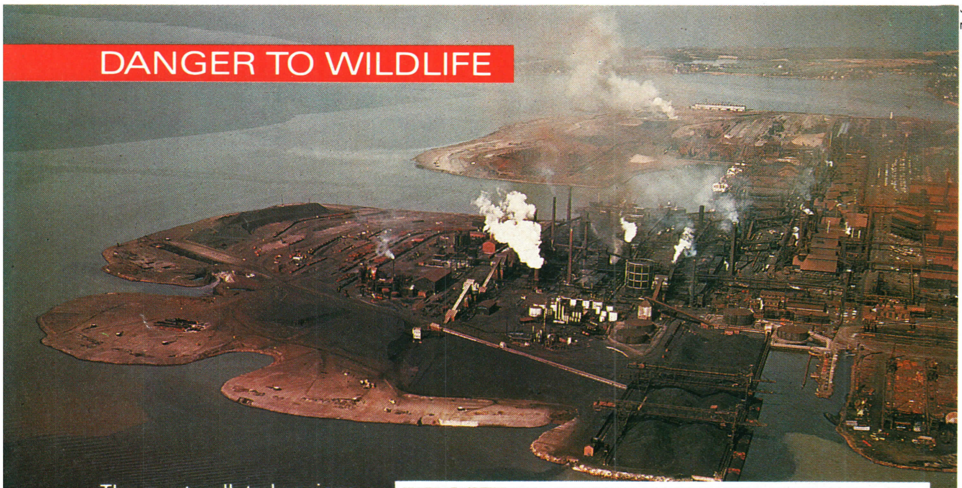
Waste dumped *from ships is eventually washed up on to the beaches by the tides. It has been estimated that a staggering 7 million tonnes of litter is dumped into the oceans every year.*



Greenpeace/Dorreboom

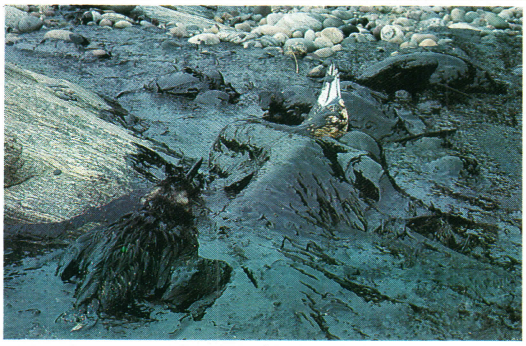
The Mediterranean *has about 30 million tonnes of sewage pumped into it every day. Plankton feed off this sewage, and use up all the oxygen in the water, causing fish to die.*

DANGER TO WILDLIFE



Zefa

The most polluted regions of the ocean are close to the land, where most of the world's fish are found. But it is not only marine life that is threatened. Birds can also meet their fate in floating oil masses.



Planet Earth Pictures/Rob Beighton

Oil pollution

When oil spills occur, they hit the headlines because of the mess and the way that the oil blankets the sea, choking birds to death and smothering sea-shore life. Between 0.5 and 1.0 million tonnes of oil enter Mediterranean waters every year, making it one of the most chronically oil-polluted areas in the world.

Fortunately, however, oil is biodegradable. This means that, in time, bacteria and other micro-organisms will get to work on the oil and eventually break it down into harmless compounds. In the early days, oil spills were treated with detergents, but this proved to be more damaging to marine life than the oil. Now, the policy is to try to contain the spill and stop it from reaching vulnerable areas.

Air pollution from coal-fired power stations is reduced by fitting them with devices that remove sulphur, dust and grit from the waste gases.

Martin Bond/SPL

- GAS RIGS
- GENERATING STATIONS
- NUCLEAR POWER

POWER TO THE PEOPLE

British Gas PLC

FLIP A SWITCH AND, AS IF BY magic, an electric light comes on – or a radio, a vacuum cleaner, or a heater. Twist a knob and a glowing ring of gas flames obediently springs from a cooker.

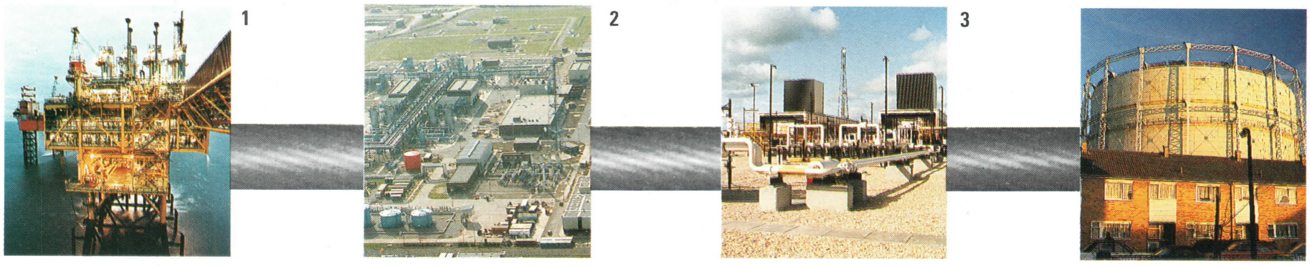
We take such things for granted, but whenever a supply is interrupted, it soon becomes obvious how totally dependent we are on these vital services.

There is far more to a city, a village, or even a single house, than meets the eye. Below ground level, safe from disturbance, cables and pipes convey electricity and gas into the very heart of our homes. Without these 'mains' services, our lifestyle would be quite different.

Natural gas *from huge offshore drilling rigs has replaced the coal gas previously produced at gasworks throughout the country.*

The modern gas industry has its origins in the late eighteenth century development of gas lighting. The use of gas for cooking and heating began in the middle of the

GAS – FROM RIG TO CONSUMER



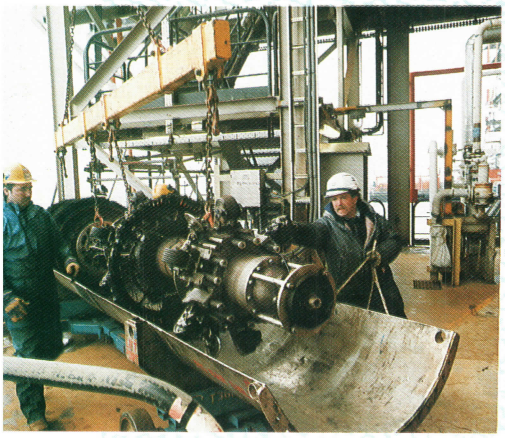
Huge rigs (**1**) recover natural gas from below the sea bed. This gas was produced by chemical reactions on the bodies of tiny sea creatures that died hundreds of millions of years ago.

Gas is piped to an on-shore terminal (**2**), where impurities are removed. Tests are carried out to check that the gas produces the right amount of heat, and a smell is added so that leaks can be detected.

Compressor stations (**3**) boost pressure at intervals along the major supply pipes. Reduction stations and regulators keep local supplies at a lower pressure. Gas storage (**4**) helps to cope with demand.

British Gas PLC

THE INTELLIGENT PIG



British Gas PLC

High-pressure gas pipelines need regular inspections. British Gas use a computerized intelligent device called the pig, which is driven along the pipes by gas pressure. It records about 750,000 measurements each second. On a typical inspection, it records 2,100 million measurements.

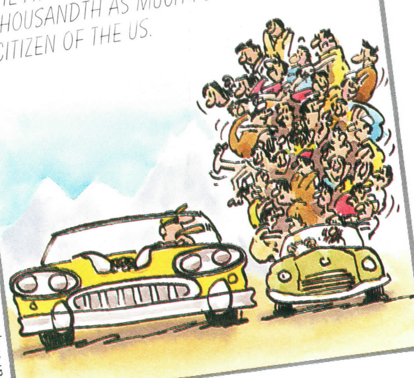
nineteenth century with the introduction of gas stoves in 1840 and gas fires in 1855. At first, most of the gas was manufactured by heating coal in the absence of air. The use of natural gas was started by the Fredonia Gas Light and Water Works Company in the US in the year 1858.

In many parts of the world there are valuable deposits of natural gas, either in association with oil or on their own. Natural gas consists mainly of methane, together with ethane and small amounts of propane, butane and nitrogen. This gas was once considered as little more than a nuisance when discovered during drilling for oil, and was merely disposed of by burning it at the oilfields. This is still done in many areas, particularly at oilfields in re-

Just amazing!

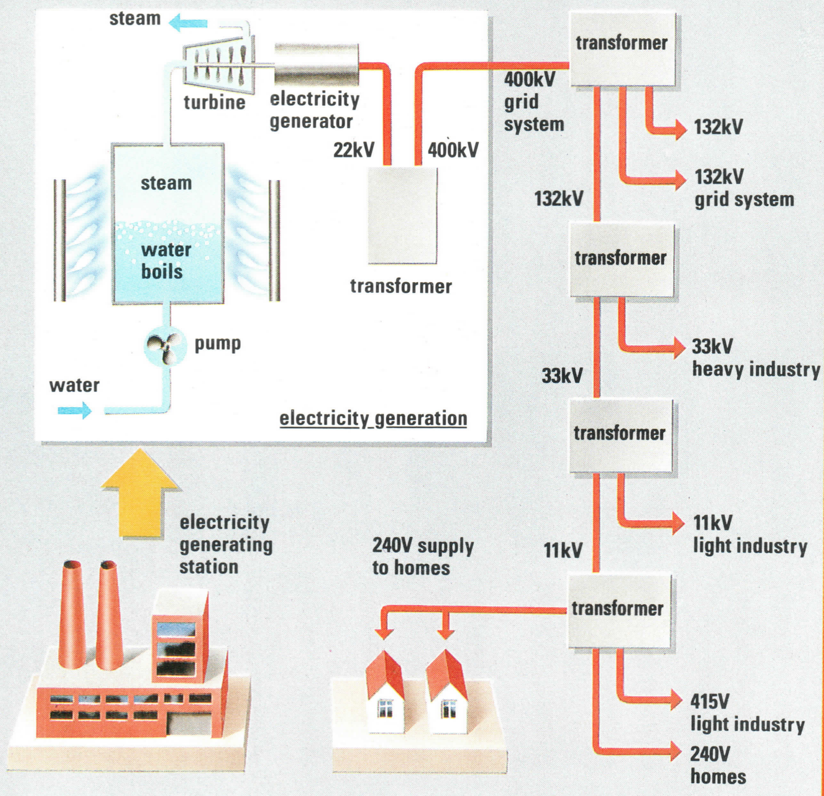
THIRSTY WORK

THIRD-WORLD CITIZENS USE MUCH LESS FUEL THAN PEOPLE IN DEVELOPED COUNTRIES. IN NEPAL, FOR EXAMPLE, THE AVERAGE PERSON USES ONLY ONE-THOUSANDTH AS MUCH FUEL AS A CITIZEN OF THE US.



Paul Raymonde

ELECTRICITY GENERATION AND DISTRIBUTION



Janos Marffy

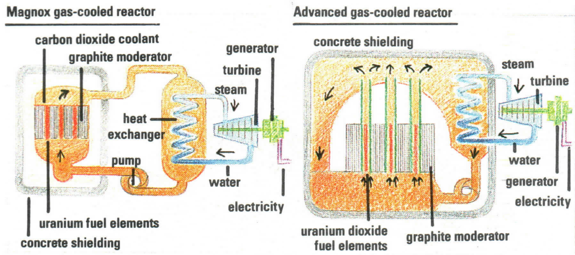
In an electricity generating power station, heat from burning coal or oil, or from a nuclear reaction, boils water to produce steam. This rotates the blades of a turbine, which turns an electricity generator. A transformer changes the 22,000 volt alternating current (22 kV AC) output from the generator up to 400 kV, as power losses are greatly reduced by transmitting electricity at a high voltage. During its distribution around the country, other transformers reduce the voltage of this major supply in stages.

Martin Bond/SPL

POWER TO THE PEOPLE

***The nuclear power** station at Strathclyde, Scotland. The two main buildings house a Magnox reactor and an Advanced Gas-cooled Reactor (AGR). The Magnox reactor uses uranium fuel, while the AGR uses enriched uranium dioxide. In both types, carbon dioxide gas absorbs heat produced in a carefully controlled nuclear reaction and transfers it to water via a heat exchanger. The water changes into steam, which turns a turbine linked to an electricity generator. The electricity is then distributed through the National Grid.*

***The Magnox** reactor's heat is carried by carbon dioxide around water-filled tubes. The water boils, and the steam drives a turbine and generator. In the AGR, water boils as it passes through the nuclear fuel chamber.*



John Hutchinson

mote desert areas far from any potential consumers of gas.

Today, however, many oil-producing countries collect and process this gas, either for export in liquefied form or to provide fuel for their own developing industries and cities.

Natural gas became the major source of gas in the US in the 1930s, following the discovery of extensive deposits and improvements in pipeline technology. There are now over 100,000 natural gas wells in the United States alone. Extensive natural gas deposits have also been found in North Africa, Russia, Australia and off the northern European coast.

North Sea gas

In Europe, one of the most significant finds of natural gas was made at Groningen, northern Holland. This strengthened the opinions of many geologists who believed that there was gas, and possibly oil, in vast quantities under the North Sea between Britain and Holland.

The first commercial find in the North Sea was made in 1965. Exploration and discovery made steady progress, and the gas was soon being piped ashore for use in Britain. Gas from beneath the bed of the North Sea is now the primary source of gas for Britain and other northern European countries.

North Sea gas is brought by pipeline from offshore drilling rigs to coastal reception terminals, and distributed by a network of more than 3,000 km of high-pressure pipelines. The gas is taken from these main pipes and distributed locally at lower pressures.

Electricity

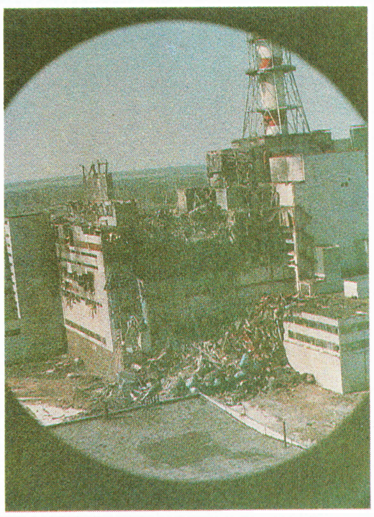
Imagine what it would be like with no record players, tape recorders, TVs, radios and refrigerators, not to mention electric lights and heaters. Yet, about a century ago, before the arrival of domestic electricity, no-one had any of these things in their home.

It was the invention of the incandescent electric light bulb in about 1879 that initiated the public demand for electrical energy, but the new form of energy was soon being used to provide heat and also power for machines. The cleanliness and flexibility of use, and the simplicity of transmission from one place to another, rendered it popular with domestic, commercial and industrial users alike.

The first public electricity supply systems were owned and operated by private companies or by local authorities. Some systems provided direct current (DC), which flows in one direction only, like the current from a battery. Others provided alternating current (AC), which rapidly alternates, or changes its direction of flow. The voltages of the various supplies differed, and the frequencies (rates of alternation) of the alternating current supplied varied too.

As the use of electricity grew, it became obvious that the supplies should be standardized throughout the country. This would not only permit the easy transmission of

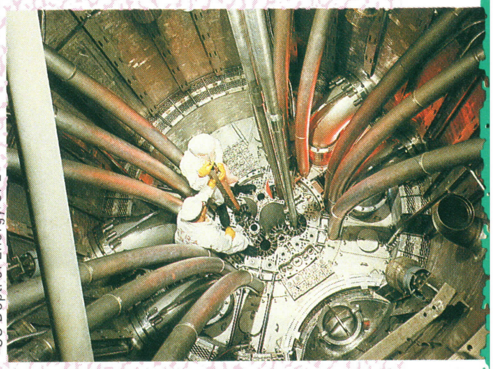
CHERNOBYL DISASTER



Rex Features

In the early hours of 26 April 1986, the unthinkable happened at a nuclear power plant in the Ukraine, then part of the USSR – a nuclear reactor blew up. The disaster occurred because safety procedures were not strictly followed. About 30 people died immediately, but up to 75,000 people may eventually die.

THE HOT SPOT



US Dept. of Energy/SPL

The core of a nuclear reactor is where matter is converted into large amounts of energy, in accordance with Einstein's mass-energy equation: $E = mc^2$. The symbol c represents the speed of light, which is very great, so c^2, or $c \times c$, is enormous. This is why the energy (E) produced by destroying a mass (m) is so great.

power from one part of a country to another, but it would also simplify the design and construction of electrical equipment.

Standardization

In Britain today, the standard supply to the home is 240 volts AC. The electricity is produced by burning coal or oil, or by the breakdown of a radioactive substance like uranium. The heat from these fuels is used to produce steam to drive turbines linked to generators.

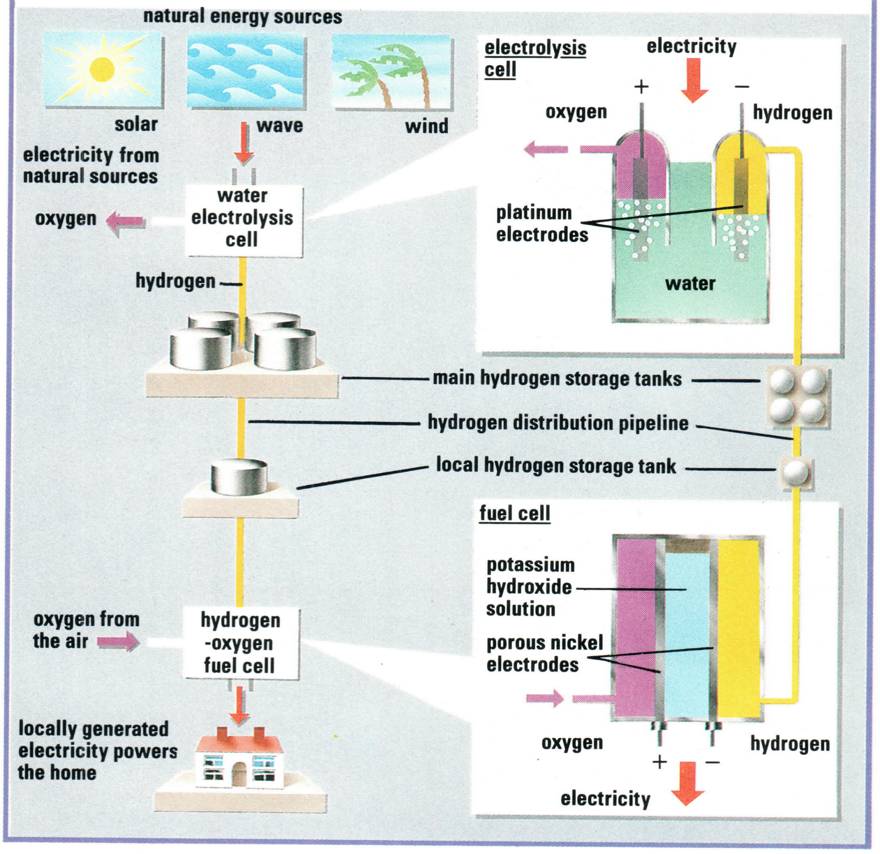
Alternating current has one great advantage over DC. Its voltage can be changed by means of a simple device called a transformer. This enables the electricity produced by generators at a power station to be converted to a much higher voltage for transmission along cables to other parts of the country. At a high voltage, less current is required to transmit a given amount of power. And the losses in the cable depend on the strength of the current. Therefore, by increasing the voltage and reducing the current, power losses are reduced, making the system much more efficient.

National supplies

In many countries, such as Britain and France, the establishment of national supply networks was followed by state ownership of the supply companies. But in 1990, most of the electricity industry in England and Wales became run by private companies again. In other countries, for example the US and Switzerland, the national network interconnects a mixture of private and public systems.

ALTERNATIVE ENERGY SOURCES

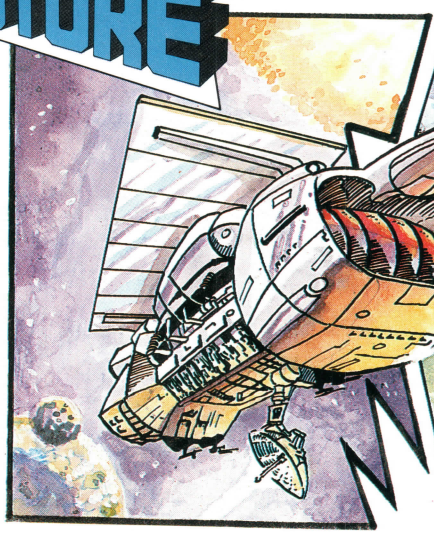
Electricity is an extremely convenient form of energy – clean, versatile and efficient. Work continues on developing effective ways of converting nature's forces, such as solar, wave, tidal and wind power, into electricity. The main problem is that the demand for electricity is not always matched by these forms of supply. What is needed is some kind of storage system so that the electricity is available when needed. One possible solution to the problem is to use electricity generated by natural forces to split water into hydrogen and oxygen (electrolysis). The hydrogen could be stored until needed and then combined in fuel cells with oxygen from the air to generate electricity again.



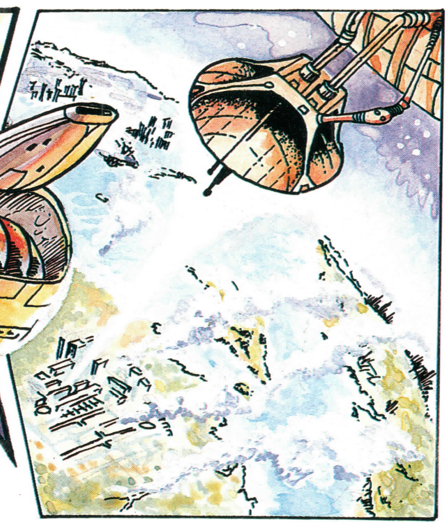
Janos Marffy

INTO THE FUTURE

MEGAWATT MICROWAVES



▲ Giant orbiting spacecraft with solar panels will collect light and heat radiation from the Sun, convert it into powerful microwaves and beam it to Earth.



▲ Enormous receiving stations will convert this energy into electricity. Unlike sunlight, the microwaves will penetrate even the densest cloud cover.

▲ A fail-safe system will be essential as the intense microwave radiation could quickly reduce a major city to ashes if a fault caused a beam to be misdirected.

Alan Burrows

Francois Gohier/Ardea

VANISHING SPECIES
GIANT DUST STORMS
ACID FROM THE SKY

THREAT TO LIFE

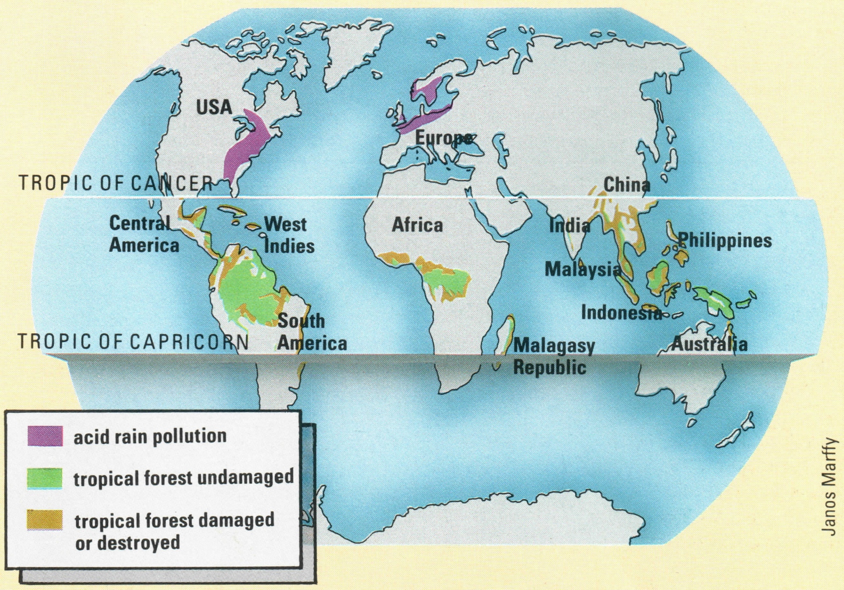
MAN SHARES THE PLANET with about 40,000 species of vertebrates – mammals, birds, reptiles, amphibians and fishes – and at least 250,000 plant species.

Conservationists calculate that ten per cent of all plant species are at risk of extinction. There are also 1,000 animal forms on the endangered species list. Yet, this is just the tip of the iceberg. By far the most numerous of Earth's species are insects. Although they outnumber the vertebrates by about 200 to one, untold numbers of insects are at risk. Pesticides are being sprayed on agricultural land, delicate environments are ploughed and bulldozed, and the massive rain forests of South America, Africa and South East Asia are being logged for timber, or cleared to make way for large-scale farms.

Between ten and twenty per cent of all living species may well have vanished by the end of the twentieth century. When the great dinosaurs and many marine creatures succumbed to extinction 65 million years ago, they disappeared at a rate of only one species every thousand years. Yet geologists refer to the period as 'the great dying'.

Every day, millions of trees are felled for timber, burned down or

REGIONS AT RISK



Janos Marffy

From the industrial regions in North America and Europe to the rain forests of Brazil, West Africa and the Pacific, Man's struggle for progress is having devastating side-effects that are endangering plant and animal life.

Acid rain, caused by fumes from factories and road vehicles, pollutes rivers, lakes, crops and natural vegetation. This problem is particularly severe in western Europe and down the eastern side of the United States.

The destruction of tropical rain forests means that many species of plants and animals will be lost forever. And, as forests absorb rainwater, their destruction often results in flooding. In India, for example, a 20 per cent loss of forests in recent years has doubled the land area liable to flooding. Already, almost 50 per cent of the world's tropical rain forests have been destroyed by man forever.

Marion Morrison/South American Pictures

***Beef production** is an expanding business in South America, so huge areas of the tropical forest have been cleared to make room for cattle ranches. This destruction puts the people who live there at risk too. Some tribes have lived in the forests for thousands of years and have established highly specialized ways of life. They have learnt to hunt the creatures of the forest and to use plants for food and medicine. Ancient cultures are being lost as the inhabitants are forced to move out.*

bulldozed by Man seeking land for farming. Each year sees an area equivalent to England and Wales razed to the ground. Already almost 50 per cent of the Earth's primal tropical forests have disappeared. Northern temperate forests can be reinstated, and this has happend to some extent in Europe and the US. But tropical forests live on a thin, fragile soil which is quickly eroded once the tree-cover has gone. And when tropical forests go, they disappear forever.

Victor Englebert/Susan Griggs Agency

***Irrigation schemes** can be used to recover vast areas of land that were once desert. However, we are still losing the battle, as much more land is being lost than reclaimed. About 230 million people are watching their land turn into desert. The rate of desert spread varies with the desert retreating in some areas.*

Food factors

The South American forest clearances have been carried out mainly in the interests of cattle ranching, which has grown enormously to satisfy North America's massive demand for beef. The forests, which contain a huge variety of plant life, much of it unknown and of potential use to Man for medicines and food, are decimated so that the burger-chains can be stocked with hamburger meat. It seems likely that powerful marketing forces will continue to increase the demand for hamburgers. So the outlook for these forests is bleak.

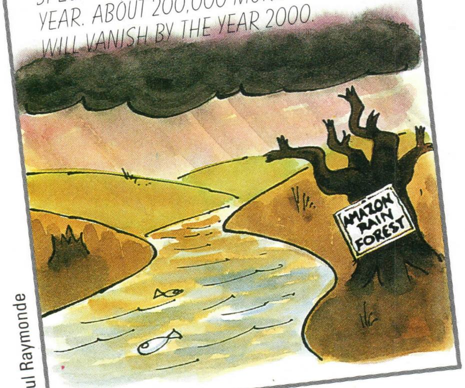
The industrialized countries of the world, accounting for about a quarter of the world's population, eat half the world's food production. Farm animals in the developed countries eat a quarter of the planet's grain in their feed – equivalent to the total human grain consumption of China and India together. It takes 16 kg of grain to produce just one kilogram of beef, and about eight kilograms of grain to produce one kilogram of pork. Meat production is, therefore, an inefficient use of our food resources. In Third World countries, however, most of the grain produced is eaten directly – mainly in the form of bread and other flour-based foods.

Deadly harvests

Man has been creating deserts for a long time. The Fertile Crescent between Jordan and Iran was the birthplace of agriculture ten million years ago. Much of it is now barren desert, because the land was repeatedly sown and harvested without being sufficiently replenished. The lush farmlands of Mesopotamia

Just amazing!

DESTRUCTION
MAN IS WIPING OUT PLANT AND ANIMAL SPECIES AT THE RATE OF 18,000 EACH YEAR. ABOUT 200,000 MORE SPECIES WILL VANISH BY THE YEAR 2000.



Paul Raymonde

THE DEADLY SPRAY

Various forms of pollution, including the spray from aerosol cans powered by chemicals called chlorofluorocarbons (CFCs), are damaging the layer of ozone gas high in the Earth's atmosphere. This layer absorbs much of the Sun's harmful ultraviolet radiation. Without this protection, plants would die, and humans would become liable to suffer from skin cancer. Even a one per cent reduction in the amount of ozone in the atmosphere would have a serious effect on human health.

Sinclair Stammers/SPL

FLOODING

The destruction of tropical forests often results in flooding when the heavy rains come. In a forested area, the tree roots absorb rainwater from the soil. The water passes up the trees and is eventually released through the leaves as water vapour. In this way, much of the water that falls is recycled into the atmosphere. However, once the trees have gone, the water level can quickly rise when it rains, causing flooding. The rain also washes away the soil, later deposited as silt.

Camerapix Hutchison Library

***Damming a river** can cause problems. The reservoir that forms may flood valuable farming land and wildlife habitats.*

Gerald Cubitt/Bruce Coleman Ltd.

(situated where Iraq is today) were turned into desert by the very water that kept them green for so long.

Long-term irrigation often has the effect of saturating the ground with salts and minerals that are left behind when the water evaporates. Eventually the earth is so full of these imported substances that they kill anything planted in it.

In part, the increasing spread of deserts, particularly in Africa, may be due to modern Man's talent for polluting the air. The gases and emissions from vehicles and factories, and the residues released into the air by burning forest-land, increasingly prevent the sun's rays from bouncing back into space once they have hit Earth. Like greenhouse glass, they reflect the bounced radiation back to Earth, heating it a second time, and creating the so-called greenhouse effect.

In the course of the last hundred years, the Earth's temperature has gradually increased by up to 0.6 of a degree Centigrade. This temperature rise, although apparently small, drives rainfall north and south – away from the areas that need it most. Meanwhile, the deserts expand and as much as 200,000 square kilometres of potential farmland a year become impossible to use for agriculture.

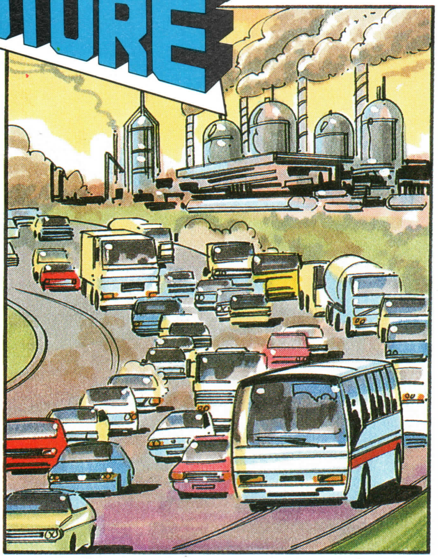
Man's abuse or neglect of the soil itself has ravaged a resource that took centuries to build up naturally. Wherever trees are cut down, there is a danger of erosion as rains and frosts break down soil, to be carried away by storms and winds.

The rain forests are particularly vulnerable. Their soil tends to be very thin, and root systems are shallow. Clearing rain forests produces land that a single grass crop will exhaust. With little growing on it, the soil will eventually crumble and blow away in the wind.

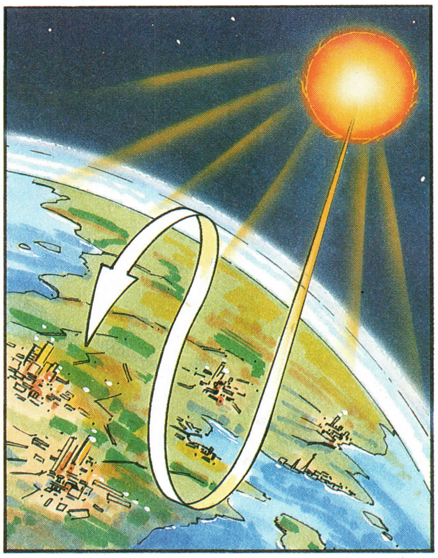
The Great Dustbowl of the US stretches across five states – Kansas, Oklahoma, Texas, Colorado and New Mexico – and was once a centre of intensive farming. The land was farmed mercilessly, without any restitution in the form of fertilizers or animal manures. As a result, in the 1930s, over 350 million tonnes of topsoil blew away.

INTO THE FUTURE

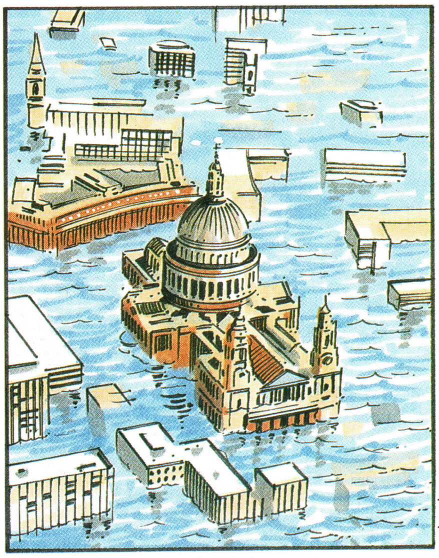
THE GREENHOUSE EFFECT



▲ *Fuels burnt in factories and road vehicles release carbon dioxide gas into the air, increasing the atmosphere's heat-trapping property – the greenhouse effect.*

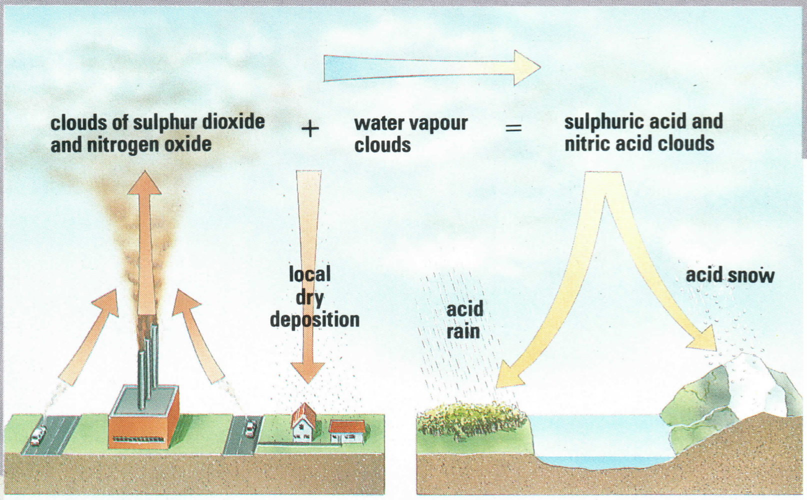


▲ *Radiation from the sun passes through the carbon dioxide and warms the Earth. But the heat reflected back from the Earth is trapped around it.*



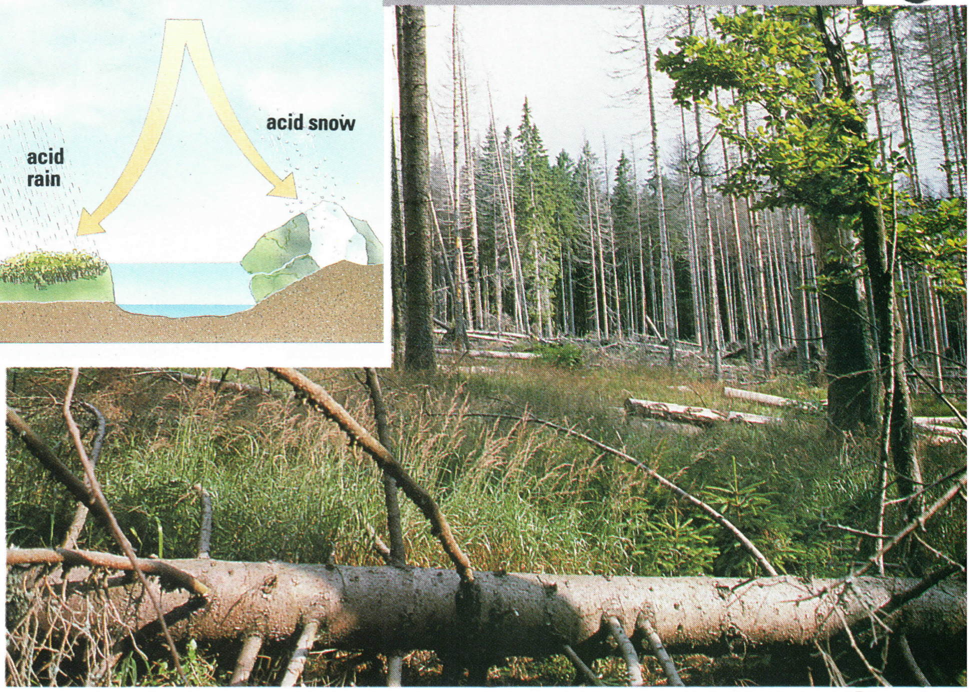
Joe Lawrence

▲ *The gradual warming of the Earth could eventually melt the polar icecaps, causing the water level in the oceans to rise and swamp the world's lowlands.*



Stan North

Acid rain pollution is an increasing problem in Western Europe. Large patches of forest have been destroyed, as the rain stripped the trees of their foliage.



G.S.F. Picture Library

Many of our industries pour sulphur dioxide and nitrogen oxide into the atmosphere. Nitrogen oxide is also released in the exhaust fumes of road vehicles. These gases together with smoke rise into the atmosphere. Some of the pollutants fall locally as dry deposition, which damages plants and affects human health. Pollution carried further into the atmosphere combines with moisture in the clouds to form clouds of dilute sulphuric and nitric acid. This eventually falls as acid rain or snow.

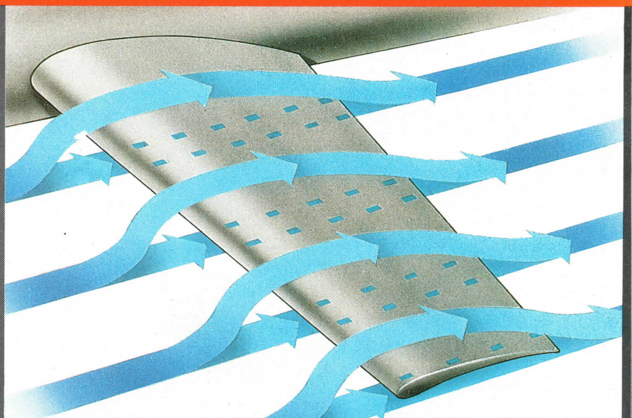
Wherever these pollutants fall, they kill plants and animals. Fish stocks are wiped out, and forests die back to brown skeletons. At first sight crystal-clear lakes in Scandinavia appear very beautiful. In fact they are so devoid of life – as a result of acid rain – that not even the murk of tiny plant cells cloud their waters. In the USA and Canada alone, 50,000 lakes may be biologically dead by the year 2000.

Polluted lakes that are too acidic for plants and animals can be partially restored. Lime is dropped into the water to neutralize the acid.

WHAT GOES UP...

Aviation Picture Library

AEROFOILS



When a wing passes through the air, the airflow divides. Air flowing over the upper surface has farther to go then air flowing underneath, so an area of low pressure is formed over the top of the wing. This creates the lift, which cancels out the weight of the aeroplane.

Mick Gillah

ALL MODERN AIRCRAFT work on the principle that air pressure drops as its speed increases – a fact first discovered in the 18th century by the Swiss doctor and mathematician Daniel Bernoulli.

To take advantage of this effect, an aircraft wing is curved on top so that, as the wing moves forward, the air above it has to travel further than the air below. As the air above the wing moves further in exactly the same time, the pressure above the wing is reduced. As a result, the excess pressure from below produces an upward force on the wing. This force – known as 'lift' – supports the aircraft as it flies.

If the angle at which the air attacks the wing is increased, air flowing over the top must accelerate even more, and so the lift is stronger. However, if the angle is increased too much, air can no longer flow smoothly around the long path above the wing, and the aircraft will lose lift and go into a stall. On modern aircraft, the angle of attack is very small, usually not more than about two degrees in level flight.

Engineers have discovered that wings with a special cross-sectional shape, called an aerofoil, are the most efficient. When the aircraft is moving slowly, flaps on the trailing edges of the wings can be lowered to make the wing more curved and increase the lift. This is done on take-off and landing.

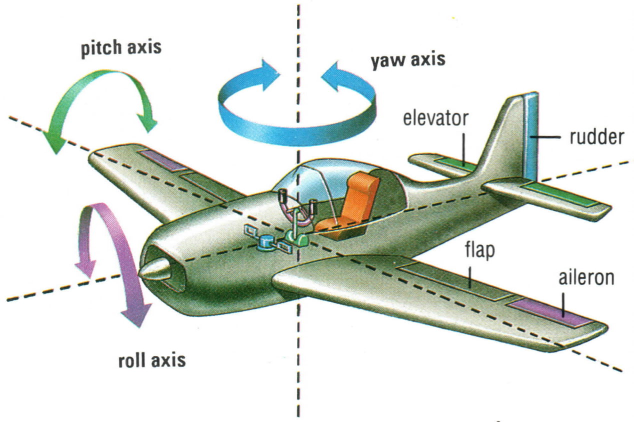
Pitch, roll and yaw

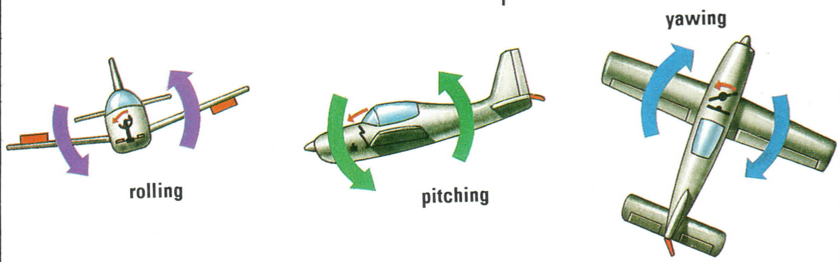
Once it is in the air, the aircraft has to be capable of changing direction in three ways – pitch, roll and yaw. The pitch of an aircraft is governed by elevators on the tailplane. Moving these up or down causes the nose to rise or fall, so that the aircraft can climb or descend.

Ailerons at the rear outside edges of the wings are used to control roll. If one aileron is raised while the other is lowered, the lift generated by each wing will differ and the

CONTROLLING AIRCRAFT MOVEMENT

Pitch (up and down movement) is controlled by the elevators – hinged surfaces on the trailing edge of the tailplane. Yaw (side-to-side movement) is achieved by moving the rudder – a flap on the tail fin. The ailerons, control surfaces on the wing tips, allow the aircraft to 'roll'.





Mick Gillah

aircraft will roll to the right or left.

If the pilot wants to turn to the right, he moves his control column to the right. This lowers the left-hand aileron and increases lift on the left-hand wing. Simultaneously, the right-hand aileron is raised and the lift on the right-hand wing is reduced. So the aircraft rolls to the right. Having rolled the aircraft in the required direction, the pilot then pitches the nose up slightly to avoid loss of height. The overall effect is that the aeroplane banks to the right.

The tail fin is fitted with a rudder, which is used to control yaw and keep the aircraft pointing in the right direction. But the aircraft is not turned using the rudder alone, as this would give insufficient control and would make the aircraft skid sideways. Proper control is obtained by banking the aircraft in the direction of the turn while using the rudder, and the passengers then experience no sideways forces.

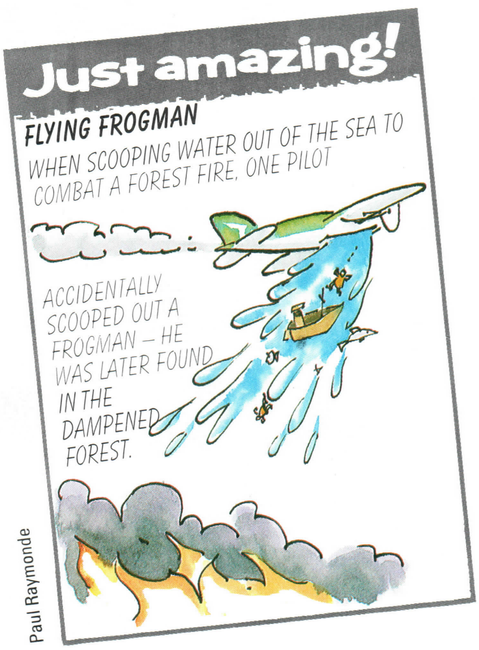
Jets and props

Forward motion is produced by a force called thrust, which is generated by the engines. Propeller-driven aircraft use piston engines or turboprops. The propeller's rotating blades force air backwards and, by an effect called reaction, produce forward motion.

A typical jet engine contains alternate rows of stationary and rotating blades, the latter being connected to a central drive shaft. Air is sucked into the front of the engine and compressed by the compressor stage. Aviation kerosene fuel is then mixed with the air and ignited in the combustion chamber. The hot gases produced rush backwards, through the turbine that powers the compressor, and then out through the nozzle, so producing the thrust which is a reaction effect.

Aviation Picture Library

On landing, *the pilot fully extends flaps on the trailing edge of the wing and opens out the slots on the leading edge, or airbrakes, situated on top of the wings. This has the effect of increasing drag and lift so reducing the speed of the aircraft as it travels along the runway and preventing a stall.*



Paul Raymonde

HEAVY AIR TRAFFIC

Heathrow, the largest of London's four airports, is also the world's main international airport. Heathrow currently handles more than 41 million passengers each year. Of these, over 34 million travel on international routes and over 7 million on domestic routes. More than 80 passenger airlines now use Heathrow, operating scheduled services to over 200 destinations throughout the world.

The airport has three runways and four passenger terminals, and a fifth terminal is planned in order to cope with the ever-increasing numbers of passengers and flights. Access to central London and main-line railway stations is provided by an underground rail link, but in order to deal with travellers more efficiently a new express rail link to Paddington main-line station is planned, which will take just 16 minutes to do the journey.

Fixed-pitch propellers *are fitted to the smallest and simplest aircraft. Variable-pitch propellers are fitted to most propeller-driven aircraft, allowing the engines to run at their most efficient speed.*

ZEFA

J. Cochin/Explorer

***The US Navy** investigated the possible military use of hot-air balloons in the 1960s. This sparked off public interest, and ballooning soon became a popular sport.*

GETTING ALOFT   HINDENBURG DISASTER   HANG GLIDING

LIGHTER THAN AIR

BALLOONS AND AIRSHIPS have one thing in common – they can fly because they are lighter than air. Unlike fixed-wing aircraft, helicopters, birds and insects, they do not need to generate a force that is greater than their own weight.

Balloons can be separated into two categories – hot-air balloons and gas-filled balloons. Hot air is less dense than cold air, so when the air in a balloon is heated, the balloon will automatically rise. The two gases commonly used in balloons are hydrogen and helium, which are both less dense than air.

One major disadvantage of gas-filled balloons, however, is their cost. While air is free, hydrogen and helium must be specially manufactured and are therefore expensive. Hydrogen is much cheaper than helium but it is also highly imflammable and extremely hazardous.

Hot-air balloons

A typical hot-air balloon has a volume of 2,180 cubic metres and contains 2.6 tonnes of air. The mass of the equipment and passengers is about 0.6 tonnes, so a little more than this mass of air must be driven out of the balloon to make it rise from the ground. This is achieved by heating the air to about 100°C, which is a typical flying temperature. The air expands as it is heated, forcing some of it out of the neck of the balloon.

Hot-air balloons are generally much bigger than gas-filled ones. To achieve the same lift as the 2,180 cubic metre hot-air balloon, a helium-filled balloon need have a volume of only 580 cubic metres, and a hydrogen-filled balloon just 540 cubic metres.

The envelope – the part that contains the air itself – is generally made from nylon or polyester and is reinforced with strong webbing.

The air is heated by one or more large burners. Propane fuel is stored as a liquid in cylinders inside the passengers' basket, which is suspended from strong steel cables. The propane passes from the cylinders through a coiled tube at the base of the burners. This causes the fuel to vaporize and emerge in the flame as a gas.

The supply of fuel to the burner is

controlled by a simple valve, which has just two positions – full on and full off. The pilot controls the balloon by varying the amount of time for which the burner is ignited. In a typical, approximately level flight, the burner will be repeatedly turned on for five seconds and then off for 20 seconds.

By skilful use of the burner valve, the pilot can control a balloon's rate of ascent or descent. Leaving the burner switched off allows the air to cool and the balloon gradually descends. The balloon will rise again when the burner is switched on.

A balloon pilot has little or no control over the direction of flight. Balloons are carried along with the wind, so there is no choice but to fly where the wind blows.

A curious effect can be noticed when flying in a balloon. Although the balloon is carried along by the wind, the passengers feel no wind at all. This is because they are travelling at the same speed and in the same direction as the wind. Therefore the relative movement between the passengers and the air around them is zero.

Airships

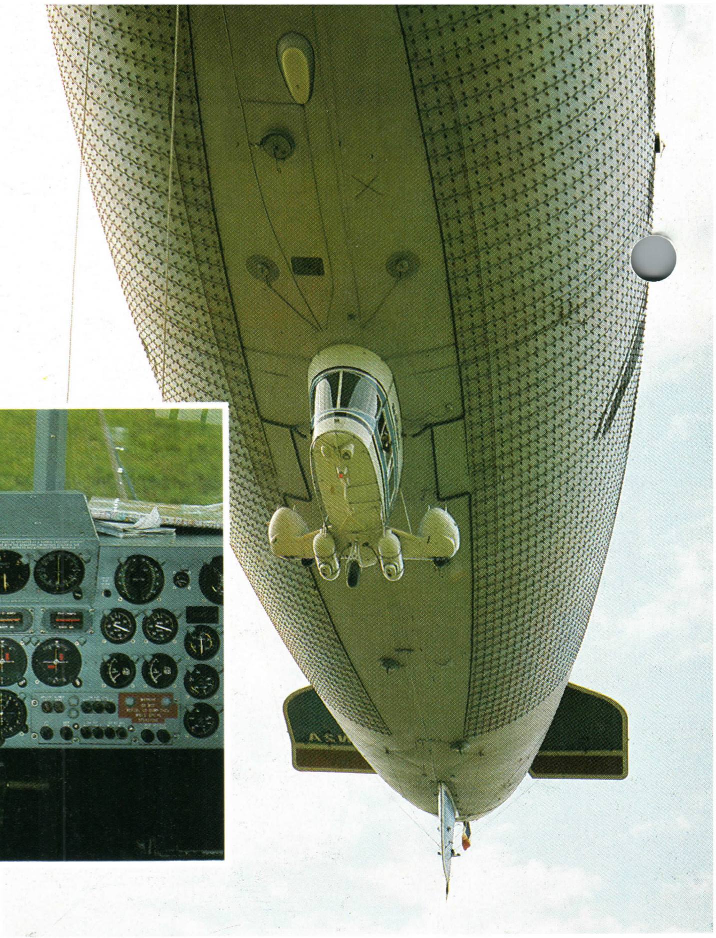
Essentially a gas-filled balloon with engines, an airship has propellers to control the direction of flight. Instead of being round like balloons, airships are long and thin. This is to reduce air resistance, so that they can pass through the air more easily.

The early years of the airship were brought to a tragic end with the loss of the *Hindenburg* Zeppelin in 1937. This huge machine, measuring some 250 metres in length, carried 100 people, and even had a dance floor!

Little work was done on airship design for several decades. The craft came back into fashion in the 1970s and 1980s. One of the new airship pioneers is the British-based company Airship Industries. Their Skyship 600 is widely used to carry tourists on sightseeing flights.

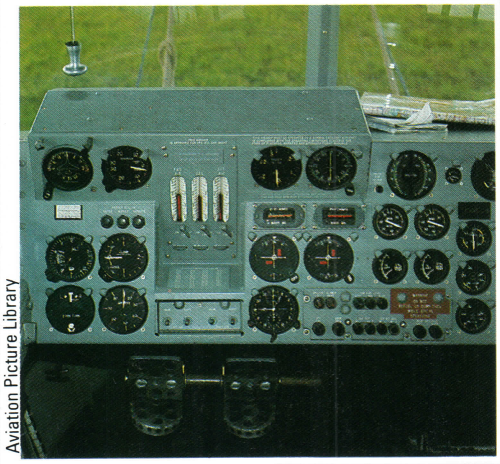
Another popular use of airships is for advertising. The airship is a large slow-moving craft that can be easily seen from the ground. Some companies have chartered airships with advertising slogans painted on the envelope, and airships have even been used to carry computer-driven illuminated signs.

One proposal for a passenger airship service in the UK has been put forward by a company based on the Isle of Man. They may operate a service from the island, situated in



***Airships** are steerable balloons. Propellers below the main structure provide thrust and, with rudders and elevators at the back, control the direction of flight. The control cabin has as many instruments as a light aircraft.*

ZEFA



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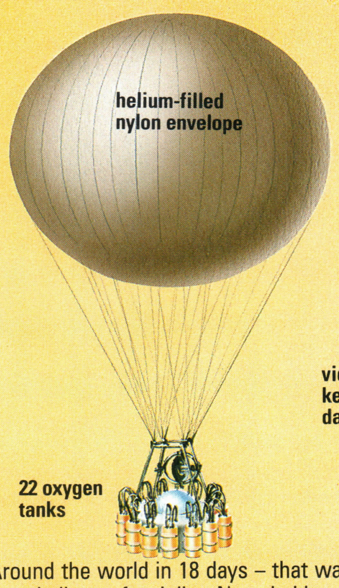
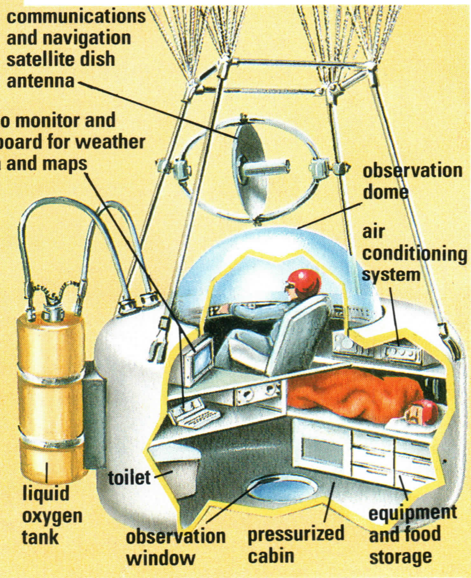




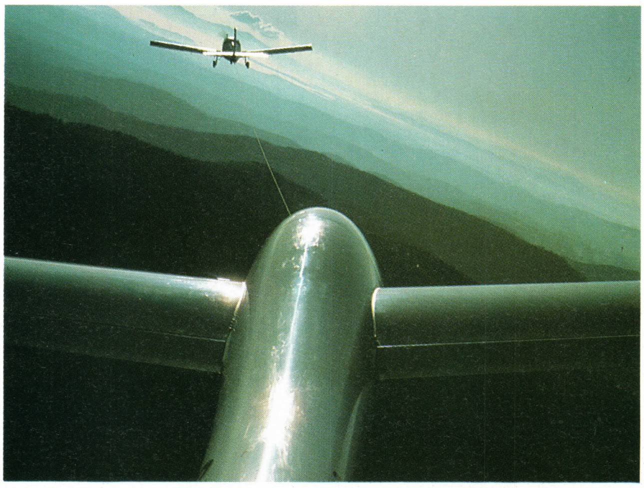
Around the world in 18 days – that was the challenge for Julian Nott, holder of numerous world ballooning records. Nott, in his helium-filled balloon called The Explorer, was accompanied by TV cameraman, Buddy Squires. The flight started in California, USA, at the end of 1992. Trade winds carried the balloon eastwards at an average altitude of 12,000 metres.

Janos Marffy

AIRSHIP INFERNO

Associated Press

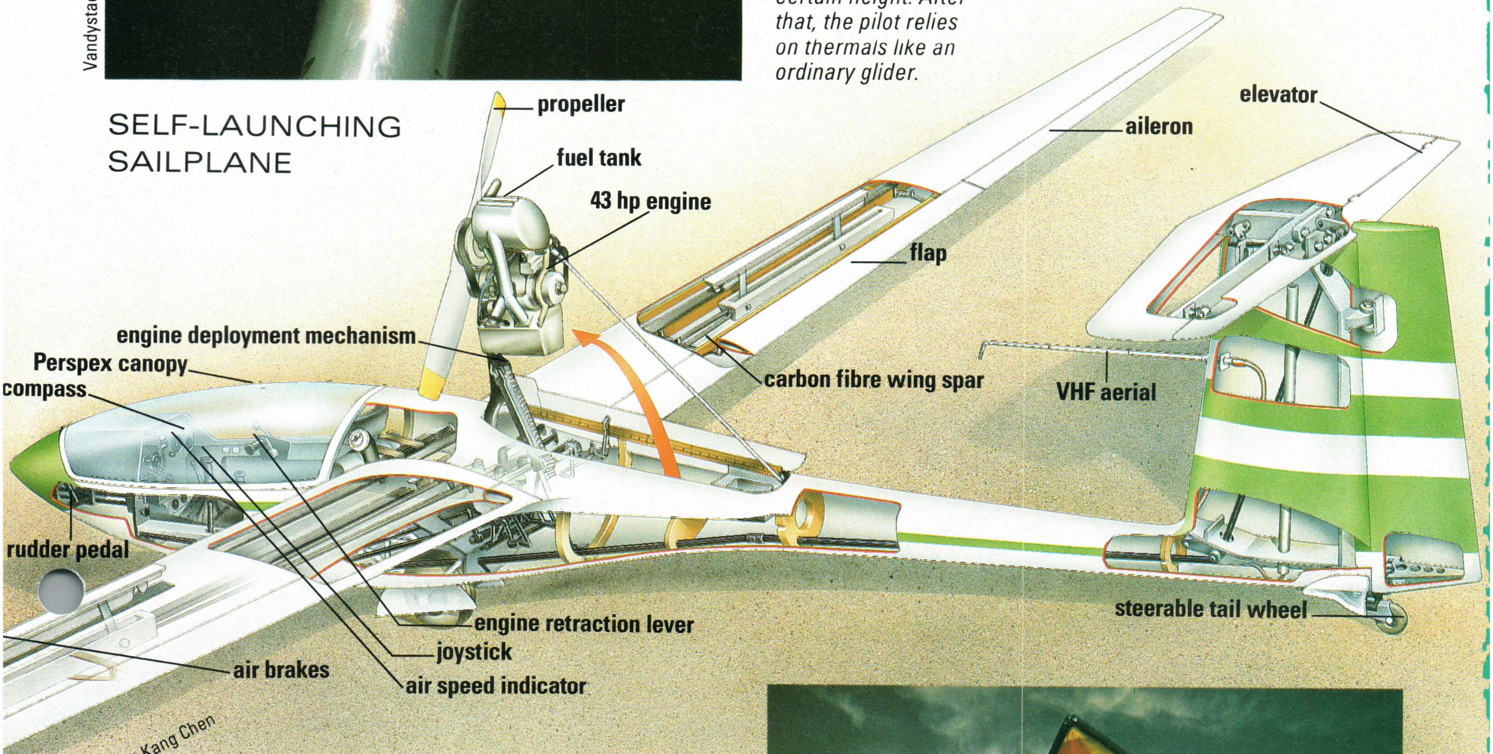
Tragedy struck the luxurious German *Hindenburg* airship in 1937, as it came down to land at New Jersey after crossing the Atlantic. The hydrogen-filled giant burst into flames, probably ignited by a spark from static electricity, or from an engine. Amazingly, 62 of the 97 people on board survived.



Vandystadt/Allsport

***Ordinary gliders** have no engine and are towed into the air, where the pilot uses thermals – rising columns of air – to stay airborne. Self-launching sailplanes (below) get into the air using an engine, which is stopped and retracted into the fuselage at a certain height. After that, the pilot relies on thermals like an ordinary glider.*

SELF-LAUNCHING SAILPLANE



Kuo Kang Chen

the Irish Sea, to Blackpool on the mainland in the north of England.

For this, they have designed a 60-metre-long airship with a volume of 7,250 cubic metres. Instead of having a rigid structure, like the early airships, the craft will be held in shape by the pressure of its helium gas. This is why the craft is known as the Advanced Non-Rigid airship, ANR. It is planned to run two airships on the Blackpool route. The ANR should be able to complete the journey in 46 minutes.

Gliders

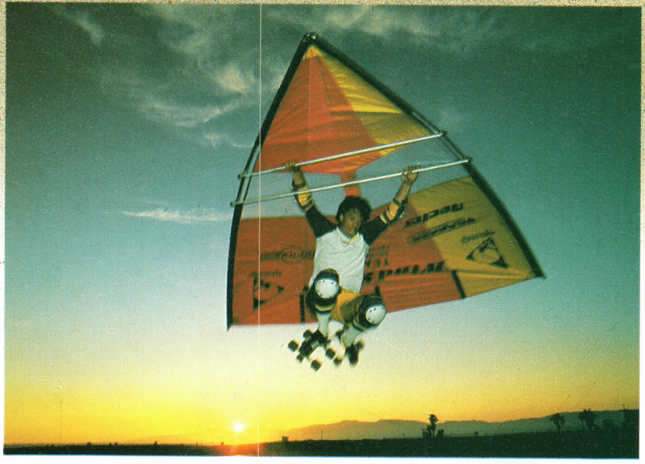
Balloons and airships are lighter than air, but some heavier-than-air flying machines can also use the wind to carry them along. These are the gliders and hang gliders. A glider is like an ordinary fixed-wing aircraft without an engine.

Gliders are usually towed along before they can get into the sky. Forward movement is needed so that air moves over the glider's wings and generates lift. Gliders can either be towed along a runway by a truck, or towed into the sky by a powered aircraft.

Once the towing cable is released by the glider pilot, he is on his own. In order to stay aloft, he must find thermals, or columns of rising air, which will give the required lift.

Hang gliding is a popular variation of gliding. It was developed in the 1970s by American engineer, Francis Rogallo. The hang glider pilot is strapped into a frame, which is suspended from a nylon sailwing.

***Windskating** is one of the simplest ways of gliding. Once the skater has gained sufficient speed on the ground, the lift force produced by the airflow past the wing will carry him into the air.*



Gamma/Frank Spooner Pictures

Vandystadt/Allsport

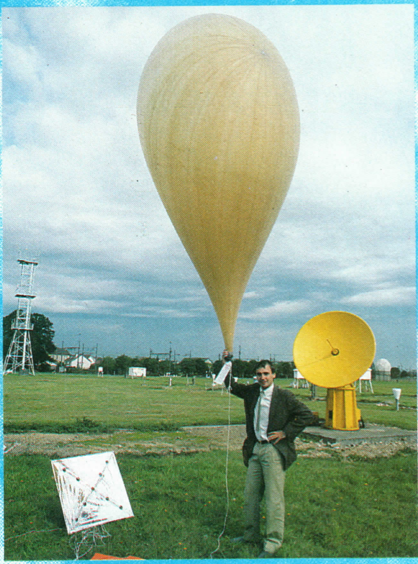
***The hang glider** is usually launched by the pilot running down the side of a hill while strapped into the harness. Take-off occurs at about 25 km/h. To steer the craft, the pilot shifts his weight by pushing against a control bar. Some modern hang gliders can cover distances of over 150 km.*

Richard Cooke

The Hot-Air Balloon Company Limited

Airships *are now used for sight-seeing trips and for carrying advertising messages over major cities. Passenger services are planned to be introduced soon.*

Weather balloons *carry instruments that sense temperature and other atmospheric conditions. They can be tracked by radar while they are carried across the earth by winds at heights of over 24 km. These gas-filled balloons expand in the thinner upper atmosphere.*


A. Guillou/Explorer

The highest trapeze *act was performed by Ian Ashpole while hanging under a hot-air balloon (above) at a height of just over 5 km, in May 1986.*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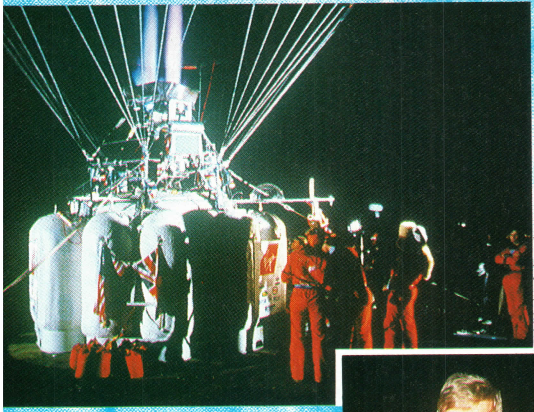

Virgin Atlantic

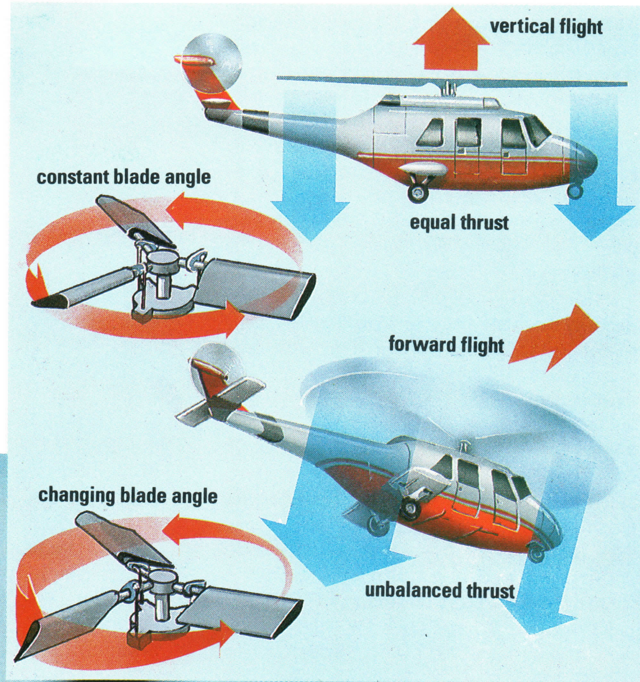
A world record *was established in 1987 when 45 people flew together in the Cameron PH-EEN balloon, more commonly known as the 'Big 850'. The 24,000 cubic metre balloon was piloted on this epic 70 minute flight by its Dutch owner, Henk Brink.*

Crossing the Atlantic *in a hot-air balloon was a remarkable achievement by Per Lindstrand and Richard Branson in July 1987. The Virgin Atlantic Flyer (above) took just 29 hours and 23 minutes to reach Ireland from Maine in the USA.*

Amazing sights *await visitors to a hot-air balloon rally. Balloons in the shape of a truck, building or bulbous bunny carry sight-seers aloft.*

Air Balloon Co. Ltd

ROTOR FORCE



Mike Saunders

***Helicopters fly** according to the angle of the blades. At a constant angle, the blades push down equal amounts of air and the helicopter rises; when the angle is increased at the back, it creates a forward thrust.*

Boeing/APL

***Boeing CH-47D Chinooks** are used by the US Army to transport its 2,268 kg trucks. Dual point suspension stabilizes the load and permits faster cruise speeds.*

AN AERIAL HOVERCRAFT, THE helicopter can take off and land vertically, and even stand still in mid-air. This gives it a great advantage over fixed-wing aircraft, for unlike them, the helicopter rises into the air and moves through it because of its rotor, or rotating blades.

When the helicopter rotor is turning, air passes over its 'wings' and the helicopter can generate enough lift to take off vertically. But to do this, it requires three to ten times the power needed by a typical aeroplane.

Helicopters are extremely difficult to fly, requiring great co-ordination between hands and feet. The left hand operates the collective lever. This changes the pitch of all the blades by the same amount. An increase in pitch results in increased lift. Decreasing the lift makes the helicopter hover or descend.

Helicopter control

The right hand controls the cycle stick. This regulates the horizontal motion through the air. To make the helicopter move forward, the rotor is tilted forward slightly, and to go backwards, the rotor is tilted in the opposite direction. Left and right turns are made by tilting the rotor sideways.

The feet operate pedals that control the tail rotor. This is a compensating rotor, usually smaller, that balances the twisting tendency produced by the main rotor turning in one direction.

Some helicopters, like the Boeing CH-47D Chinook, have two main rotors that rotate in opposite directions. The movement of one cancels out the other, so twin rotor helicopters do not need tail rotors.

Its ability to take-off and land vertically makes the helicopter ideal for use in difficult terrain, where they have to get in and out without long runways.

In city centres, where space is at a premium, helicopters are playing an increasing role in getting passengers in and out of built-up areas. Most lighthouses are now fitted with helicopter landing pads and so are oil rigs around the world.

Helicopters are also used by the armed forces to transport men and machines, or as ground-attack aircraft. The helicopter provides a very stable weapons platform.

New hybrid

Electronic systems, including auto pilot, and new, lighter materials continuously contribute to more efficient helicopter design. But the inherent nature of the helicopter's flight means that it cannot fly much faster than about 380 km/h. This is because, beyond that speed, no more lift can be achieved by the retreating blades – whatever the angle of the pitch – while the advancing blades tilt the helicopter uncontrollably to the left.

The solution lies in a hybrid between a fixed wing and a rotor aircraft, such as the tilt-rotor Osprey and the part-chopper, part-jet, X-wing.

For landing and take-off, the Osprey hovers like a helicopter, but once in the air, the engine housing and rotors tilt forward 90 degrees to become an aeroplane. The X-wing, too, takes off and lands vertically using its rotors, but in flight, the rotor becomes stationary.

FLYING JUGGERNAUT

Aviation Picture Library

The largest helicopter in the world is the Soviet-built Mil Mi-26 Halo. The Mi-26 first flew in 1977, made its debut with the military in 1983, and was fully operational two years later.

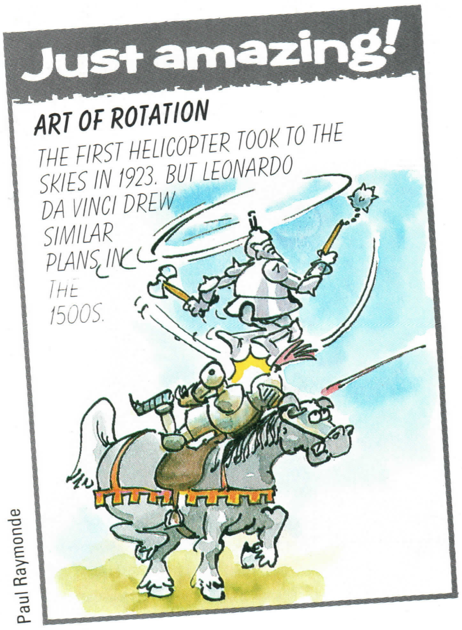
The Halo has eight blades on its main rotor, which measures 32 metres in diameter, and is powered by two Lotarev D-136 engines, which can each produce 16,760 kW of power.

The fuselage is 33.7 metres long which is comparable with that of a C-130 Hercules. The Mi-26 weighs 28 tonnes and can normally lift a payload of 20 tonnes. In 1982, at Podmoscovnoe in the then Soviet Union, an Mi-26 lifted a total mass of 56.77 tonnes to a height of 2,000 metres, setting a new world record.

The Mi-26 carries a crew of five, has a range of 800 km and can fly at a maximum speed of 295 km/h. More than 50 have been built, and it is still in production.

Aviation Picture Library

The Soviet Mil Mi-24 *Hind helicopter can carry air-to-ground and air-to-air missiles. The Hind A, B and C are assault helicopters. The Hind D, E and F are used in anti-tank operations. Hind helicopters were used extensively in Afghanistan during the Soviet occupation in the 1980s.*

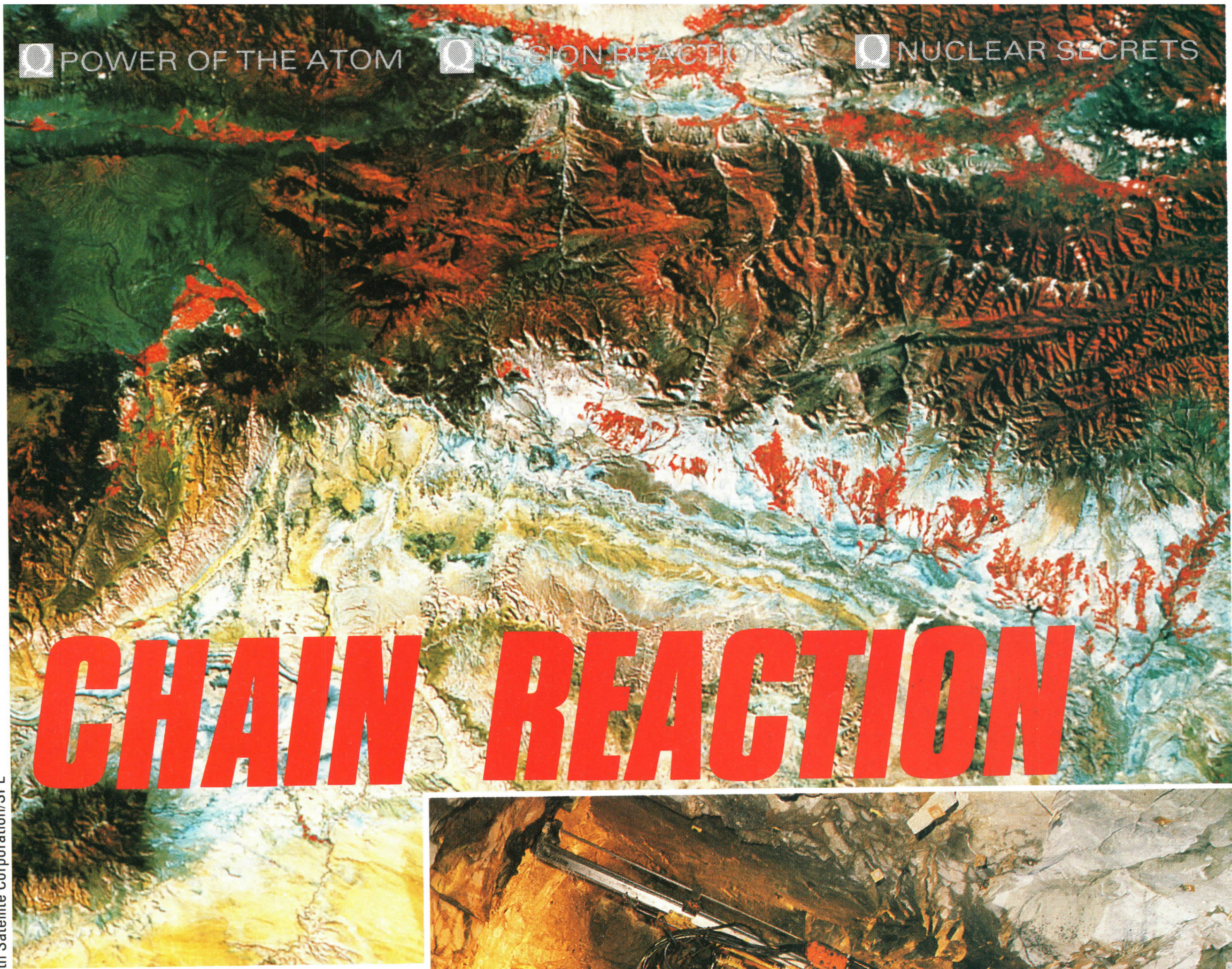


Paul Raymonde


McDonnell Douglas Corporation

Future fighters, *such as the LHX, designed by McDonnell Douglas and Bell, will fulfill the US Army's requirement for high-technology, agile, multirole helicopters that can be used for combat and reconnaissance.*

CHAIN REACTION



Earth Satellite Corporation/SPL

Satellite photographs *showing different surface rocks in false colours help geologists to find uranium deposits.*

RTZ

AT THE CENTRE OF ATOMS IS the source of the devastating power behind Man's most destructive weapons – nuclear bombs. And yet atoms are extremely small. A row of ten million atoms would measure only one millimetre from end to end.

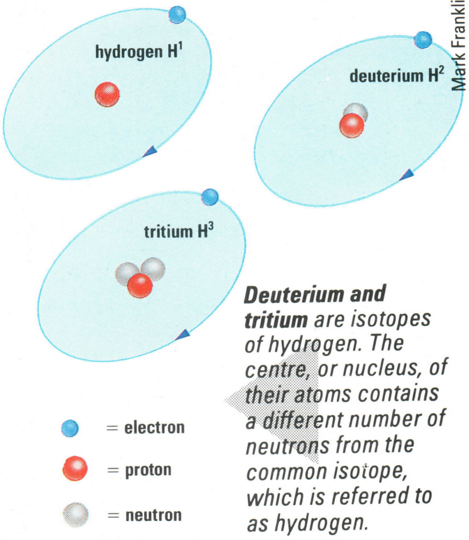
All matter, whether solid, liquid or gas, living or non-living, is made up of these tiny particles. And each atom consists of even smaller particles called neutrons, protons and electrons. The protons and neutrons are bunched together to form the central core, or nucleus, of the atom, with the electrons (which are very much smaller) spinning around it like planets going around the sun.

What makes an atom of one element different from that of another is the number of protons and neutrons in its nucleus. For example, the nucleus of a hydrogen atom is just a single proton, while the nucleus of a carbon atom has six protons and six neutrons. Uranium atoms are far bigger and heavier.

The most common type of uranium is uranium-238 (U-238). Its nucleus has 238 particles: 92 protons and 146 neutrons. About 99.3 per cent of natural uranium is U-238. The other 0.7 per cent is mainly uranium-235 (U-235), which has the same number of protons, but three fewer neutrons in its nucleus. These different forms of the same element are called isotopes.

Because uranium atoms are so big, the atomic forces binding the protons and neutrons within each nucleus can only just hold the whole thing together. The atoms

Mining uranium *in Ontario, Canada. The rocks are dug out, crushed, and then treated with chemicals to produce 'yellow cake'. This oxide contains about 85% of uranium by weight.*



Mark Franklin

Deuterium and tritium *are isotopes of hydrogen. The centre, or nucleus, of their atoms contains a different number of neutrons from the common isotope, which is referred to as hydrogen.*


U.S. Department of Energy/SPL

***Fatal cancer** is the likely outcome of inhaling just one thousandth of a gram of plutonium. To protect workers, plutonium is handled on glovebox conveyors.*

are liable to break up, and the reactions that occur when this happens release vast amounts of energy.

Splitting the atom

In any piece of uranium, there will always be a few atoms that become unstable and break up, scattering their protons and neutrons. Some of these will recombine, forming the smaller atoms of lighter elements, such as krypton or barium.

Any spare neutrons will usually fly straight out of the uranium through spaces between the atoms. But some neutrons collide with the atoms. If a neutron hits a U-238 atom, it will either bounce off it or, if it is going slowly enough, it will be absorbed by the atom.

But if a neutron crashes into a U-235 atom, it will split the atom in two. This splitting, called nuclear fission, releases energy from within the nucleus – along with two or three spare neutrons, which can go on to split yet more U-235 atoms.

Nuclear weapons

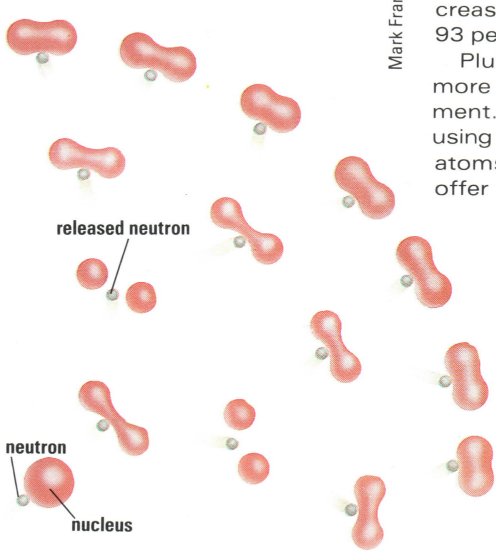
If the piece of uranium is big enough, and contains a high enough percentage of U-235 atoms among the U-238, the chances of a spare neutron hitting and splitting a U-235 atom are much increased. And, if the conditions are right, this fission process will continue until all the U-235 atoms have been split up.

This sequence of neutrons splitting atoms, producing more neutrons, which split even more atoms, is called a chain reaction. During a chain reaction, a huge amount of energy is released from within the atoms.

In a nuclear power station, the reaction is carefully controlled. It spreads very slowly, and the heat energy it releases is used to boil water and produce steam. This drives turbines linked to generators to produce electricity. In an atomic bomb, however, a chain reaction takes place almost instantaneously, and the energy released creates a massive blast.

The hydrogen bomb is even more powerful. It uses the heat from an atomic bomb to set off a fusion reaction. Two isotopes of hydrogen, called deuterium and tritium, fuse (join) together with the sudden release of an enormous amount of energy.

In order for a fission reaction to take place, the uranium used must contain a higher proportion of U-235 than the 0.7 per cent naturally present in it. So, before it can be used, the uranium must be enriched to increase its U-235 content – to at least 90 per cent for bombs and about 2 to 4 per cent for reactors.



Mark Franklin

***A chain reaction** starts when a free neutron splits the nucleus of an atom, such as uranium-253. In the process, more neutrons are released, and these split more of the uranium atoms. The reaction continues in this way, releasing large amounts of energy in the process.*

Uranium enrichment

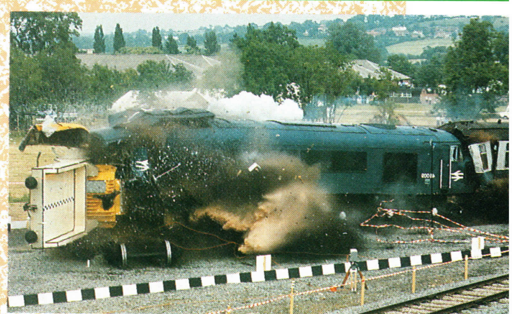
Because the technology needed to enrich uranium reactor fuel can also be used to make highly enriched uranium for atomic bombs – weapons-grade uranium – the countries that have the technology try to keep the details of it very secret. Many countries now have nuclear power stations, but most of them have to buy their enriched reactor fuel from nations with enrichment plants. However, an increasing number of countries have managed to build their own enrichment plants, and this gives them the ability to make atomic bombs. These countries include the UK, USA, Russia, France and possibly India, Pakistan, South Africa, Israel, Argentina, Iran and Iraq.

Plutonium production

Plutonium can also be used both as a reactor fuel and for making bombs. Only minute amounts of plutonium occur in nature. When the uranium-238 in a nuclear reactor absorbs neutrons, it changes into plutonium (Pu). For weapons, this plutonium must be enriched to increase its Pu-239 content to at least 93 per cent.

Plutonium enrichment is even more difficult than uranium enrichment. But new techniques, such as using laser beams to separate Pu-239 atoms from vaporized plutonium, offer a relatively quick and cheap way of making weapons-grade plutonium from reactor waste. This may lead to an alarming growth in the number of countries producing nuclear weapons and an increasing danger of nuclear war. There would also be a greater risk of nuclear weapons getting into the hands of terrorists.

THE ULTIMATE TEST


CEGB

A collision between a 160 km/h train and an empty nuclear fuel transport flask was staged to demonstrate that moving radioactive materials by rail was perfectly safe. This followed the expression of fears by people living near the railway routes concerned. After the crash, the flask was intact.

FUEL FOR LIFE

Eva Momatiuk & John Eastcott/Susan Grig... set Dianne/Jerrican

***Fast food**, though colourful and attractive, makes a poor substitute for proper meals.*

***Fish keeps an Eskimo fit.** Essential fatty acids from fish oils combat the high dosage of animal fat in an Eskimo's diet.*

WHEN THE AUSTRALIAN Aborigine eats a tasty grub and the Masai warrior drinks warm blood from a cut in the neck of a cow, they are both taking in vital nutrients.

Despite their great variety of diets, all human beings require the same nutritional elements. These are proteins, fats, carbohydrates, vitamins, minerals, fibre and water.

Proteins

About 18 per cent of human body-weight consists of proteins. These are very complex structures made up of chains of building blocks called amino-acids. There are at least 22 amino-acids. They combine in varying ways to form the different proteins.

The proteins found in meat, fish, milk and eggs have all the essential amino-acids and are said to be of High Biological Value (HBV). The proteins found in vegetables, nuts and grains lack one or more of the essential amino-acids and are considered of Low Biological Value (LBV), except for soya bean which has HBV protein.

However, this does not mean that LBV proteins are inferior. They can be combined with HBV proteins or different LBV proteins can be combined, such as beans with grains, to provide the essential amino-acids.

The body needs protein in order to grow, so it is particularly important for children. Protein also helps the body repair damaged tissue. In most societies, proteins, such as meat, fish, cheese and eggs, are the most expensive form of basic food. However, beans, peas, lentils, whole cereal grains and nuts are also an important source of proteins, especially for vegetarians.

Nutritionists recommend that an adult eats about 0.7 gm of protein per kg of bodyweight every day. Children need about twice this proportion, and pregnant women need slightly more than this average requirement, so that the foetus can grow satisfactorily.

In famine areas, a lack of proper dietary protein often results in 'kwashiorkor', a dietary deficiency disease affecting children. Their growth is stunted, they are anaemic and their livers deteriorate. Milk can cure it, but all too often, kwashiorkor results in death.

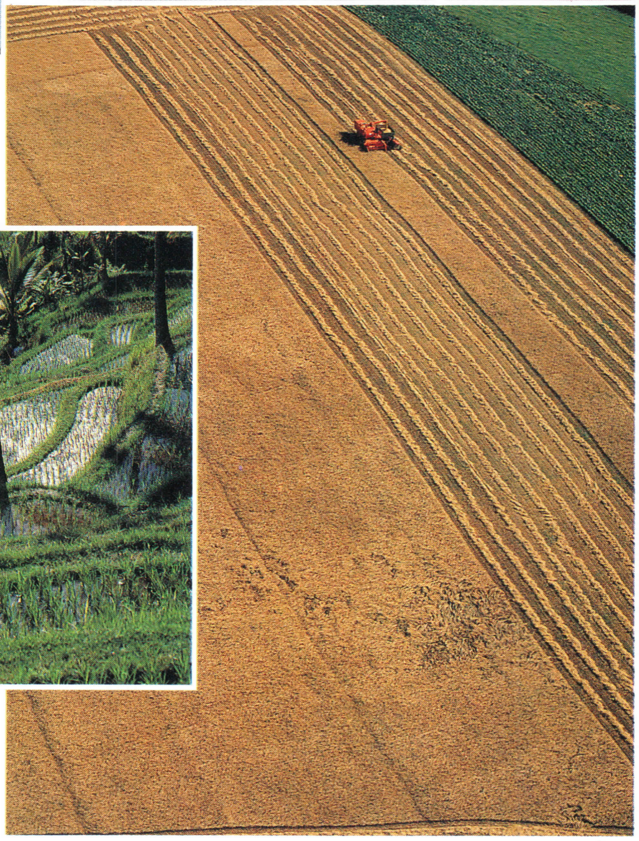
Fats

Food fats, which can be solid or liquid, are obtained directly from meat, fish, nuts, seeds and some

A B C OF VITAMINS – FOODS THAT SUPPLY THEM AND WHAT THEY DO

					The B Complex				
VITAMIN	A Retinol	D Cholecalciferol	E	K	B1 Thiamine	B2 Riboflavin	Nicotinic acid	B12 Cobalamin	C Ascorbic acid
Function	Helps form visual purple in retina to help see in dark Keeps mucous membranes moist and infection free Maintains healthy skin Promotes growth in children	Helps absorb calcium and phosphorus which are required for bone and teeth formation	An anti-oxidant. It protects against the accumulation of biological toxins.	Helps produce coagulants in blood for clotting	Helps release energy from carbohydrates Promotes growth in children Maintains healthy nerves	Promotes normal growth Helps release energy by oxidation of amino-acids and fats	Helps release energy by oxidation, especially of carbohydrates	Required for metabolism of amino-acids and enzymes in body	Helps make connective tissue which holds cells together Helps absorb iron Helps strengthen bones and teeth Helps build and maintain skin and lining of digestive passage
Found in	(As retinol:) Milk, cheese, egg yolk, butter, oily fish, fish liver oil (As carotene:) Carrots, spinach, watercress, prunes, cabbage, tomatoes, apricots, parsley	Liver, fish liver oils, oily fish, egg yolk, milk and its products, margarine, sunlight	Lettuce, seeds, peanuts, wheat-germ oil, grasses, milk and milk products, egg yolk	Leafy vegetables and in the intestine	Cereals, yeast, all meat, eggs, fish roe and milk				Rosehips, blackcurrants, green peppers, oranges, grapefruits, lemon, strawberries, cabbage, spinach, broccoli, Brussel sprouts, potatoes
Deficiency diseases	Night blindness Drying out of skin and mucous membranes Children's growth retarded	Rickets in children, Osteomalacia in adults Children's growth retarded	Anaemia, nervous disorders, muscle weakness.	Deficiency disease is rare	Depression, loss of memory and concentration Children's growth retarded Neuritis Beri beri	Lack of growth Dermatitis and conjunctivitis Swollen tongue, sore mouth	Dermatitis Dementia Diarrhoea	Anaemia with enlarged red blood cells	Loss of connective tissue Broken blood vessels Painful joints and muscles Bleeding gums, loose teeth Scurvy
	FAT SOLUBLE				WATER SOLUBLE				

***Paddy fields** are a common sight in South East Asia where rice forms the staple diet.*



***Wheat** forms the staple in more temperate climes where it is used chiefly in bread.*

Telegraph Colour Library Inset Robert Harding Picture Library

vegetables. Fats are made up of a combination of glycerol and fatty acids, the basic components of which are hydrogen, oxygen and carbon. There are at least 40 fatty acids and, depending on how their carbon and oxygen atoms are arranged, they are classed as saturated or unsaturated fatty acids.

Unsaturated fatty acids are found mostly in oil extracted from vegetables, nuts and fish livers, or in fatty fish. Fats which are solid at room temperature, such as lard, are high in saturated fatty acids. Eating too many saturated fatty acids increases the cholesterol level in blood, which can lead to heart disease. But 'sea-food' fatty acids, found in fish oils, lower blood-cholesterol levels.

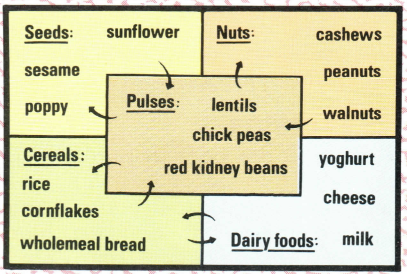
Fats are important to cell structure. Because they are also much more efficient, weight for weight, than protein or carbohydrate in storing energy for future use, any excess is retained by the body, literally, as fat.

Most fruits and vegetables contain less than one per cent fat; red meat is generally 30 per cent fat and 15 per cent protein, though pale meats, such as rabbit and chicken, are lower in fat. The white of an egg has only a trace of fat, while the yolk is about 30 per cent fat. This is why body-builders and weight-lifters will consume as many as two dozen egg-whites at one go, to obtain the high protein content – half that of beef – without the high fat content of the yolks.

Carbohydrates

Carbohydrates are the major source of energy. They, too, are made up of carbon, oxygen and hydrogen atoms. Starchy carbohydrates are

MEATLESS PROTEINS



Meatless proteins are best eaten in combination (as above) to give a full complement of amino acids.

found in rice, wheat and other cereals, as well as pasta and potatoes. Sugary carbohydrates are found in honey, syrups and in both refined and unrefined sugar.

In the body, carbohydrates are quickly and easily converted into glucose which is used to provide energy. A small portion of glucose is stored in muscles as glycogen. A man weighing 70 kg has about 368 gm of stored glycogen.

Unrefined starchy carbohydrates and fruits are a good source of fibre which is essential for digestion. Lack of fibre is linked with certain cancers.

Telegraph Colour Library

***Japanese meals**, designed to please the eye and the palate, are made up of nutritious elements, such as mineral-rich seaweed.*

Rex Features

***The milk round** in Georgia, Eastern Europe draws all generations. The natives here boast very long lives, thanks partly to milk-derived products, such as yoghurt. Milk, an almost complete food, forms the diet of babies until they are weaned.*

Vitamins

Another group of vital nutrients supplied by food is vitamins. They are necessary only in small quantities and most of them cannot be made in the body but have to be found in the diet.

Vitamins are water-soluble or fat-soluble. They are popularly known by letters, but they also have their own names. Vitamins A, D, E and K are fat-soluble, while vitamins C and the B-complex are water-soluble.

Minerals and water

Apart from the vitamins, minute quantities of a range of minerals are required to build the body, control certain functions and to form a part of body fluids.

Some minerals, such as calcium, iron, phosphorus, potassium, sulphur and magnesium are required in larger quantities than iodine, copper, manganese, fluoride, cobalt, nickel, zinc and chromium – these are needed in tiny quantities and so are known as trace elements.

Water, too, is a vital element necessary for the upkeep of the human body; in fact, 70 per cent of the body is made up of water. It is an essential ingredient of all body fluids, such as blood, urine, saliva and sweat. It keeps the mucuous membranes, bronchial tubes and the digestive system moist and also helps lubricate the joints.

Most foods contain water, especially fruits and vegetables. A minimum of two or three litres is a recommended daily intake.

Just amazing!

FIRST, FIND AN EGG . . .

FOR SPECIAL FEASTS, BEDOUINS WILL PREPARE A ROAST CAMEL, WHICH IS STUFFED WITH A SHEEP, WHICH IS STUFFED WITH A WHOLE CHICKEN, WHICH, IN TURN, IS STUFFED WITH FISH, WHICH IS ULTIMATELY STUFFED WITH EGGS.

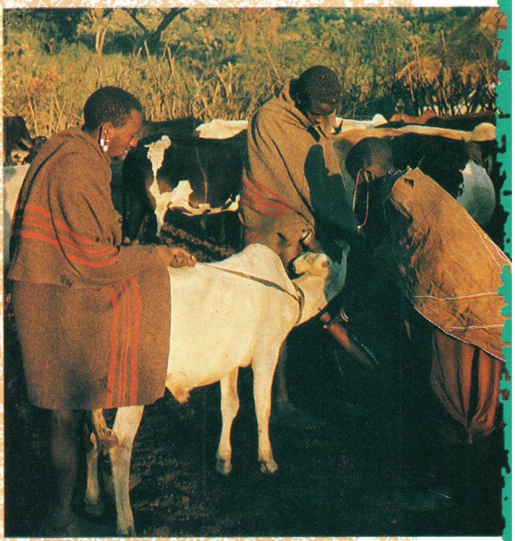
Paul Raymonde

CUSTOM AND PRACTICE

There is little that grows on our planet that someone will not eat – and much that many won't. Geography, culture and religion are only some of the factors that determine the great variety of diets worldwide. But in spite of the diverse ingredients used, humans have developed well-balanced diets to suit their circumstances.

The sinuous Masai of East Africa are herdsmen, counting their wealth in cattle which they rarely slaughter. But they regularly collect and drink their animals' blood to supplement their simple diet of fruit, milk and small quantities of meat.

Some religions, such as certain forms of Hinduism and Buddhism, advocate vegetarianism. Vegans (very strict vegetarians) do not eat eggs or dairy products – only plant foods such as cereals, pulses and seeds, as well as fruit and vegetables. Orthodox Muslims and Jews do not eat pork and only eat other prescribed meats that come from ritually slaughtered animals. Orthodox Jews do not eat shellfish and do not mix milk and meat.



Robert Harding Picture Library

Keith Scholey/Planet Earth Pictures

One man's vermin *is another's appetizer. Freshly caught bats and rats are considered good enough to eat in Indonesia where they are sold by the roadside.*

Cephas Picture Library

They eat horses *in France and Belgium – and so would the rest of Europe were it not for an 8th-century ban by Pope Gregory III to differentiate between newly-converted Christians and horse-eating pagans.*

Jeremy Thomas/Biofotos

Coming out of their shells *to mate, two edible snails ensure the supply of a favourite French dish. Some are sold ready-filled with garlic butter (below). The French eat 40,000 tonnes a year, but only farm a fifth of that. Snail farms from abroad, including Britain, supply the rest.*

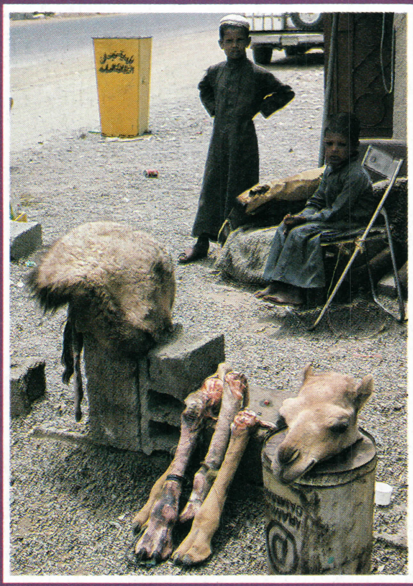
Cephas Picture Library

Char-broiled locusts *are a Burmese delicacy. Entomophagy – eating insects – is common in many parts of the world. Insects provide protein and vitamins.*

Image Bank

Heather Angel

Fillet snake *on sale in a Shanghai market. Some animals are eaten for a belief in their powers – in China, snakes are thought to be an aphrodisiac.*



Peter Stephenson/Planet Earth Pictures

A camel has many uses. *In the desert, where livestock can be scarce, it continues to serve to the end, providing animal protein for the Arabian diet.*

Pussy in the pot *is how this cat in a Chinese market will end up. Dogs are also bred and sold for food since no social taboo exists on eating animals that would be cherished as pets in other countries.*

Heather Angel